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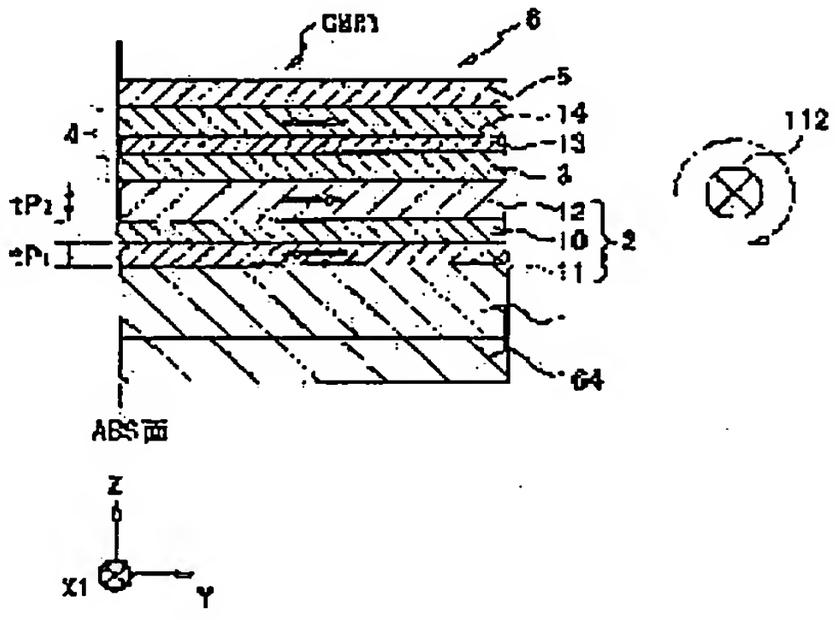
(54) SPIN-VALVE TYPE MAGNETORESISTANCE EFFECT DEVICE AND THIN-FILM MAGNETIC HEAD WITH THE DEVICE, AND METHOD OF MANUFACTURING THESE DEVICES

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a spin-valve magnetoresistance effect device having the ferri-pinned layer structure which can reduce the asymmetry and a thin-film magnetic head with this device and also provide a method of manufacturing these devices.
SOLUTION: This spin-valve magnetoresistance effect device comprises an antiferromagnetic layer 1, first fixed magnetic layer 11, nonmagnetic intermediate layer, second fixed magnetic layer 12, nonmagnetic conductive layer 3, free magnetic layer 4, vertical bias layer 7, and pair of lead layers 8. Under the condition that a detection current is supplied from the lead layers, the free magnetic layer is magnetized uniformly in such a direction as to cross with the magnetized direction of the second fixed magnetic layer. The magnetized direction of the second fixed magnetic layer is aslant at an angle θ with a direction vertical to the track width direction, which is turned toward the direction, going away from the direction of a vertical bias magnetic field.



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CLAIMS

[Claim(s)]
[Claim 1] It is formed in contact with an antiferromagnetism layer and this antiferromagnetism layer. By the exchange anisotropy field with said antiferromagnetism layer The 1st fixed magnetic layer to which the magnetization direction was fixed, and the 2nd fixed magnetic layer by which it was formed in said 1st fixed magnetic layer through the nonmagnetic interlayer, and the magnetization direction was arranged with the magnetization direction of said 1st fixed magnetic layer, and anti-parallel, The free magnetic layer formed in this 2nd fixed magnetic layer through the nonmagnetic conductive layer, The vertical bias layer which impresses a field crosswise [truck] to said free magnetic layer, It is the spin bulb mold magneto-resistive effect component equipped with said 2nd fixed magnetic layer, the nonmagnetic conductive layer, and the lead layer of the pair which gives a detection current to a free magnetic layer. Where the detection current from said lead layer is supplied, the magnetization direction of said free magnetic layer is arranged in the magnetization direction of said 2nd fixed magnetic layer, and the crossing direction. The magnetization direction of said 2nd fixed magnetic layer is a spin bulb mold magneto-resistive effect component characterized by coming to incline at an include angle theta in the direction which keeps away from a vertical bias field to the truck cross direction and a perpendicular direction.
[Claim 2] It is formed in contact with an antiferromagnetism layer and this antiferromagnetism layer. By the exchange anisotropy field with said antiferromagnetism layer The 1st fixed magnetic layer to which the magnetization direction was fixed, and the 2nd fixed magnetic layer by which it was formed in said 1st fixed magnetic layer through the nonmagnetic interlayer, and the magnetization direction was arranged with the magnetization direction of said 1st fixed magnetic layer, and anti-parallel, The free magnetic layer formed in this 2nd fixed magnetic layer through the nonmagnetic conductive layer, The vertical bias layer which impresses a field crosswise [truck] to said free magnetic layer, It is the spin bulb mold magneto-resistive effect component equipped with said 2nd fixed magnetic layer, the nonmagnetic conductive layer, and the lead layer of the pair which gives a detection current to a free magnetic layer. Where the detection current from said lead layer is supplied, the magnetization direction of said free magnetic layer is arranged in the magnetization direction of said 2nd fixed magnetic layer, and the crossing direction. The magnetization direction of said free magnetic layer is a spin bulb mold magneto-resistive effect component characterized by coming to incline at an include angle theta towards the magnetization direction of said 2nd fixed magnetic layer to the truck cross direction.
[Claim 3] The spin bulb mold magneto-resistive effect component according to claim 1 or 2 characterized by said include angles theta being 2 times or more and 30 degrees or less.
[Claim 4] The spin bulb mold magneto-resistive effect component according to claim 1 or 2 characterized by said include angles theta being 3 times or more and 15 degrees or less.
[Claim 5] The spin bulb mold magneto-resistive effect component according to claim 1 or 2 characterized by said include angles theta being 3 times or more and 10 degrees or less.
[Claim 6] The spin bulb mold magneto-resistive effect component according to claim 1 to 5 characterized by coming to make the include angle of the magnetization direction of said free magnetic layer, and the magnetization direction of said 2nd fixed magnetic layer to make into 90 degrees in the condition that said detection current is supplied and the external magnetic field is not impressed.
[Claim 7] The relation of the magnetic thickness of the 2nd fixed magnetic layer is satisfied. the case where the product of saturation magnetization Ms and Thickness t is made into magnetic thickness -- the magnetic thickness of the 1st fixed magnetic layer -- < -- The direction of the detection current field which acts on a free magnetic layer And the 2nd magnetization direction and reverse sense of a fixed magnetic layer, Namely, the spin bulb mold magneto-resistive effect component according to claim 1 to 6 characterized by coming to make into the 2nd sense and reverse sense of magnetization of a fixed magnetic layer the direction of the detection current field which acts on the 2nd fixed magnetic layer.
[Claim 8] Any one sort of Pt, Pd, Rh, Ir, Ru, and the Os or two sorts or more, and X' are a spin bulb mold magneto-

resistive effect component according to claim 1 to 7 which said antiferromagnetism layer is formed with a XMn alloy or a XMnX' alloy, and is characterized by X consisting of any one sort of Au, Ag, Cr, nickel, Ne, Ar, Xe, and the Kr, or two sorts or more.

[Claim 9] The spin bulb mold magneto-resistive effect component according to claim 1 to 8 characterized by coming to make into 96 or more kA/m the synthetic exchange anisotropy field which said antiferromagnetism layer makes act to the laminating mold fixed magnetic layer possessing said 1st fixed magnetic layer and said nonmagnetic interlayer, and said 2nd fixed magnetic layer.

[Claim 10] The spin bulb mold magneto-resistive effect component according to claim 1 to 9 characterized by coming to carry out the laminating of said antiferromagnetism layer, the 1st fixed magnetic layer, a nonmagnetic interlayer, the 2nd fixed magnetic layer, a nonmagnetic conductive layer, and the free magnetic layer to this order on a substrate.

[Claim 11] The spin bulb mold magneto-resistive effect component according to claim 1 to 10 characterized by coming to divide said free magnetic layer into the 1st free magnetic layer and the 2nd free magnetic layer through a conductive interlayer.

[Claim 12] The spin bulb mold magneto-resistive effect component according to claim 1 to 11 characterized by coming to carry out the laminating of said free magnetic layer and nonmagnetic conductive layer, the 2nd fixed magnetic layer, a conductive interlayer, the 1st fixed magnetic layer, and the antiferromagnetism layer to this order on a substrate.

[Claim 13] The thin film magnetic head characterized by coming to have a spin bulb mold magneto-resistive effect component according to claim 1 to 12 as a read-out component of magnetic information.

[Claim 14] On a substrate, at least With an antiferromagnetism layer, the 1st fixed magnetic layer, and a nonmagnetic interlayer When the layered product equipped with the 2nd fixed magnetic layer, the nonmagnetic conductive layer, and the free magnetic layer is formed, The process which forms membranes, impressing the 1st field to the 1st direction of the truck cross direction, or its 180-degree opposite direction at the time of said free magnetic layer membrane formation, and gives uniaxial anisotropy crosswise [truck] to said free magnetic layer, Impressing the 2nd field in the 2nd direction of which the include-angle theta inclination was done to the direction which intersects perpendicularly with the truck cross direction at said layered product, or its 3rd direction of a 180-degree opposite direction Heat-treat with the 1st heat treatment temperature, and the interface of said antiferromagnetism layer and said 1st fixed magnetic layer is made to generate an exchange anisotropy field. As opposed to the direction which intersects perpendicularly magnetization of said 1st fixed magnetic layer, and magnetization of the 2nd fixed magnetic layer with said truck cross direction an include-angle theta inclination The process which is the direction carried out and is mutually fixed to 180-degree opposite sense, The process which forms the vertical bias layer for impressing a bias field to said free magnetic layer in the both sides of said layered product, The process which performs 2nd heat treatment with the 2nd heat treatment temperature, impressing the 3rd field to said free magnetic layer in the 1st direction of the truck cross direction, or its 180-degree opposite direction, and gives uniaxial anisotropy again to said free magnetic layer, The manufacture approach of the spin bulb mold magneto-resistive effect component characterized by providing the process which impresses the 4th field in the 4th direction opposite to the sense of the vector component of the truck cross direction of magnetization of said 2nd fixed magnetic layer, and magnetizes said vertical bias layer.

[Claim 15] When the value which integrated thickness to the magnetic moment of each of said fixed magnetic layer is made into magnetic thickness and magnetic thickness of the 2nd fixed magnetic layer is made larger than the magnetic thickness of said 1st fixed magnetic layer, said 2nd field by considering as 400 or more kA/m [whether the direction of magnetization of said 1st fixed magnetic layer is turned in the 2nd direction which impresses said 2nd field, and the direction of magnetization of said 2nd fixed magnetic layer is turned in the 3rd direction opposite 180 degrees, and] Said 2nd field by or the thing to consider as the range of 8 - 80 kA/m The manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 14 characterized by turning the direction of magnetization of said 1st fixed magnetic layer in the 3rd direction opposite to the 2nd direction which impresses said 2nd field, and turning the direction of magnetization of said 2nd fixed magnetic layer in said 2nd direction.

[Claim 16] The value which integrated thickness to the magnetic moment of each of said fixed magnetic layer is made into magnetic thickness. Magnetic thickness of said 1st fixed magnetic layer is made larger than the magnetic thickness of said 2nd fixed magnetic layer. When said 2nd field is carried out in 400kA/m or more, the direction of magnetization of said 1st fixed magnetic layer is turned in the direction which impresses said 2nd field. By turning the direction of magnetization of said 2nd fixed magnetic layer in the 3rd direction opposite 180 degrees, or making said 2nd field into the range of 8 - 80 kA/m The manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 14 characterized by turning the direction of magnetization of said 1st fixed magnetic layer in the 2nd direction which impresses said 2nd field, and turning the direction of magnetization of said 2nd fixed magnetic layer in the 3rd direction opposite to said 2nd direction.

[Claim 17] The manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 14 to 16 characterized by having a heat treatment process for forming the induction type magnetic head for record on said layered product between said 1st heat treatment and 2nd heat treatment.
[Claim 18] The manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 14 to 17 characterized by providing the process which heat-treats by impressing a field to said free magnetic layer before the process which forms said induction type magnetic head for record in the 1st direction of the truck cross direction, or its 180-degree opposite direction, and gives uniaxial anisotropy crosswise [truck] to a free magnetic layer.
[Claim 19] The manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 14 to 18 characterized by making it smaller than the 2nd field which performs the 3rd field impressed in said 2nd heat treatment in said 1st heat treatment.
[Claim 20] The manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 14 to 19 characterized by making into 8 or more kA/m and 5 kA/m or less the 3rd field impressed in said 2nd heat treatment.
[Claim 21] The manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 14 to 20 characterized by making said 2nd heat treatment temperature below into 513K (240 degrees C) more than 433K (160 degrees C) while making said 1st heat treatment temperature below into 553K (280 degrees C) more than 503K (230 degrees C).
[Claim 22] The manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 14 to 21 characterized by forming said antiferromagnetism layer with a XMn alloy or a XMnX' alloy, and making any one sort of Pt, Pd, Rh, Ir, Ru, and the Os or two sorts or more, and X' into any one sort of Au, Ag, Cr, nickel, Ne, Ar, Xe, and the Kr, or two sorts or more for X.
[Claim 23] The manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 14 to 22 characterized by considering as the configuration which has arranged said antiferromagnetism layer between a substrate and a free magnetic layer as said layered product.
[Claim 24] On a substrate, at least With an antiferromagnetism layer, the 1st fixed magnetic layer, and a nonmagnetic interlayer In case the layered product equipped with the 2nd fixed magnetic layer, the nonmagnetic conductive layer, and the free magnetic layer is formed The process which forms membranes, impressing the 1st field to said free magnetic layer in the 1st direction of the truck cross direction, or its 180-degree opposite direction, and gives uniaxial anisotropy crosswise [truck] to said free magnetic layer, Impressing the 2nd field in the direction which intersects perpendicularly with the truck cross direction at said layered product The process which heat-treat with the 1st heat treatment temperature, and the interface of said antiferromagnetism layer and said 1st fixed magnetic layer is made to generate an exchange anisotropy field, and fixes the magnetization direction of said 1st fixed magnetic layer and the 2nd fixed magnetic layer in the direction which intersects perpendicularly with the truck cross direction, The process which forms the vertical bias layer for impressing a bias field to said free magnetic layer in the both sides of said layered product, It heat-treats with the 2nd heat treatment temperature, impressing the 3rd field to said free magnetic layer in the 1st direction or said 1st direction, and 180-degree opposite direction of the truck cross direction. As opposed to the direction which intersects perpendicularly the magnetization direction of said 1st fixed magnetic layer and the 2nd fixed magnetic layer crosswise [said / truck] while giving uniaxial anisotropy again to said free magnetic layer an include-angle theta inclination The process fixed in the direction carried out, The manufacture approach of the spin bulb mold magneto-resistive effect component characterized by providing the process which impresses the 4th field in the direction opposite to the sense of the vector component of the truck cross direction of magnetization of said 2nd fixed magnetic layer, and magnetizes said vertical bias layer.
[Claim 25] The value which integrated thickness to the magnetic moment of each of said fixed magnetic layer is made into magnetic thickness. When magnetic thickness of said 1st fixed magnetic layer is made larger than the magnetic thickness of the 2nd fixed magnetic layer, The manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 24 characterized by turning the direction of magnetization of said 1st fixed magnetic layer in the direction which impresses said 2nd field, and turning the direction of magnetization of said 2nd fixed magnetic layer to an opposite direction the 180 degrees.
[Claim 26] The value which integrated thickness to the magnetic moment of each of said fixed magnetic layer is made into magnetic thickness. Magnetic thickness of said 1st fixed magnetic layer is made larger than the magnetic thickness of said 2nd fixed magnetic layer. When said 2nd field is made into 400 or more kA/m, the direction of magnetization of said 1st fixed magnetic layer is turned in the direction which impresses said 2nd field. While turning the direction of magnetization of said 2nd fixed magnetic layer in the 3rd direction opposite 180 degrees, said 2nd field by considering as the range of 8 - 80 kA/m The direction of magnetization of said 1st fixed magnetic layer is turned in the 2nd direction which impresses said 2nd field. The manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 24 characterized by turning the direction of magnetization

of said 2nd fixed magnetic layer in the 3rd direction opposite to said 2nd direction.
[Claim 27] The value which integrated thickness to the magnetic moment of each of said fixed magnetic layer is made into magnetic thickness. Magnetic thickness of said 1st fixed magnetic layer is made smaller than the magnetic thickness of the 2nd fixed magnetic layer. When said 2nd field is carried out in 400kA/m or more, the direction of magnetization of said 1st fixed magnetic layer is turned in the direction which impresses said 2nd field. The direction of magnetization of said 2nd fixed magnetic layer is turned in the 3rd direction opposite 180 degrees. When said 2nd field is made into the range of 8 - 80 kA/m, the direction which impresses said 2nd field, and the direction of the magnetization of said 1st fixed magnetic layer to a 180-degree opposite direction are turned. The manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 24 characterized by turning the direction of magnetization of said 2nd fixed magnetic layer in the direction which impresses said 2nd field.
[Claim 28] The manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 24 to 27 characterized by having a heat treatment process for forming the induction type magnetic head for record on said layered product between said 1st heat treatment and the 2nd heat treatment.
[Claim 29] The 3rd field impressed in said 2nd heat treatment is the manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 24 to 28 characterized by being smaller than said 2nd impression field.
[Claim 30] The manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 24 to 29 characterized by making said 2nd heat treatment temperature below into 513K (240 degrees C) more than 433K (160 degrees C), and making 1st heat treatment temperature below into 553K (280 degrees C) more than 503K (230 degrees C).
[Claim 31] The manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 24 to 30 characterized by forming said antiferromagnetism layer with a XMn alloy or a XMnX' alloy, and making any one sort of Pt, Pd, Rh, Ir, Ru, and the Os or two sorts or more, and X' into any one sort of Au, Ag, Cr, nickel, Ne, Ar, Xe, and the Kr, or two sorts or more for X.
[Claim 32] The manufacture approach of the spin bulb mold magneto-resistive effect component according to claim 24 to 31 characterized by considering as the configuration which has arranged said antiferromagnetism layer between a substrate and a free magnetic layer as said layered product.
[Claim 33] The manufacture approach of the thin film magnetic head characterized by having the process which enforces the manufacture approach of a spin bulb mold magneto-resistive effect component according to claim 14 to 33, and forms the magneto-resistive effect mold component as a read-out component, and a process for forming the induction type magnetic head for record on said layered product.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the thin film magnetic heads equipped with the spin bulb mold magneto-resistive effect component and it from which electric resistance changes with the relation between the direction of magnetization of a free magnetic layer, and the direction of magnetization of a fixed magnetic layer, and those manufacture approaches, and it relates to the technique in which asymmetry can be decreased in the condition of having made the detection current field acting while it has the structure which divided the fixed magnetic layer to two-layer especially.
[0002]
[Description of the Prior Art] Conventionally, the AMR (Anisotropic Magnetoresistance) head using the anisotropy magneto-resistive effect phenomenon as a magneto-resistive effect mold reading head (MR head) and the GMR (Giant Magnetoresistance: giant magneto-resistance) head using the spin dependence scattering phenomenon of conduction electron are known, and the spin bulb (Spin-Valve) head which shows a high magneto-resistive effect by the low external magnetic field is known as one example of a GMR head. Drawing 22 is the sectional view showing the structure at the time of seeing the conventional spin bulb mold magneto-resistive effect component from an opposed face side with a record medium, and the laminating of the antiferromagnetism layer 102 and the fixed magnetic layer 103 is carried out to order on the substrate 101 in drawing 22 . The laminating of said fixed magnetic layer 103 is carried out so that the antiferromagnetism layer 102 may be touched, in the interface of the fixed magnetic layer 103 and the antiferromagnetism layer 102, a switched connection field (exchange anisotropy field) occurs, and magnetization of said fixed magnetic layer 103 is being fixed for example, in the direction of illustration Y.
[0003] On said fixed magnetic layer 103, the nonmagnetic conductive layer 104 formed by Cu etc. is formed, and the laminating of the free magnetic layer 105 is further carried out on said nonmagnetic conductive layer 104. The hard bias layers 106 and 106 formed with the CoPt (cobalt-platinum) alloy are formed in the both sides of said free magnetic layer 105, and by said hard bias layers 106 and 106 being magnetized in the direction of illustration X, magnetization of said free magnetic layer 105 is arranged in the direction of illustration X, and is single-domain-ized. Fluctuation magnetization of said free magnetic layer 105 and fixed magnetization of said fixed magnetic layer 103 are considered as the relation which intersects about 90 degrees by this. In addition, in drawing 22 , a sign 108 is a current lead layer which consists of Cu formed on the hard bias layer 106.
[0004] In the spin bulb mold magneto-resistive effect component of the above configuration While a detection current (sense current) is passed by the component from said current lead layer 108 If the direction of magnetization of said free magnetic layer 105 arranged in the direction of illustration X is changed by the leak field from magnetic-recording media, such as a hard disk Electric resistance can change by relation with the direction of fixed magnetization of the fixed magnetic layer 103 fixed in the direction of illustration Y, and the electrical-potential-difference change based on this electric resistance value change can detect the leak field from a magnetic-recording medium.
[0005] In the above spin bulb mold magneto-resistive effect components, although the one where the asymmetry (Asymmetry: asymmetry of a playback wave) of that output is smaller is desirable, this asymmetry is prescribed by the relation between the direction of fluctuation magnetization of the free magnetic layer 105, and the fixed magnetic layer 103. For example, it is so desirable that the relation between fluctuation magnetization of the free magnetic layer 105 and fixed magnetization of the fixed magnetic layer 103 is close to 90 degrees in the condition that the external magnetic field is not acting, and it is desirable that it is 90 degrees ideally.
[0006] Here, it explains below based on the simple mimetic diagram shown in drawing 23 about the direction of fluctuation magnetization of the free magnetic layer 105 which influences the asymmetry of an output. In the spin bulb mold magneto-resistive effect component of the type which reads magnetic information by having the fixed magnetic layer 103 and the free magnetic layer 105, and passing a detection current as simplified and shown in

drawing 23 The field by which magnetization of the free magnetic layer 105 is influenced The anti-field Hd which will act by this magnetization Mp if magnetization of the fixed magnetic layer 103 to which the direction of magnetization was fixed is set to Mp (dipole field), It is thought that they are the detection current field (sense current field) Hj by the detection current J and the interaction field Hint by the interaction between layers of the free magnetic layer 105 and the fixed magnetic layer 103 (field which acts in the direction which is going to carry out magnetization of the fixed magnetic layer 103 and the free magnetic layer 105 to parallel).

[0007] And it will be thought that asymmetry decreases if there is little amount contributed [as opposed to the fluctuation magnetization Mf of the free magnetic layer 105 in the field of these plurality]. That is, in order to decrease asymmetry, in the condition that the external magnetic field is not impressed, it is desirable as total of a vector to have the relation of Hj+Hd+Hint=0 (in the above-mentioned formula, Hj, Hd, and Hint show vector quantity, respectively). Therefore, when manufacturing this kind of spin bulb mold magneto-resistive effect component, as it is shown in drawing 23 , the operation direction of the detection current field Hj and the interaction field Hint over magnetization of the free magnetic layer 105 is the same, and it is common to manufacture a spin bulb mold magneto-resistive effect component as what can decrease asymmetry with constituting so that it may use that the sense of the anti-field Hd differs and may become the relation of Hd=Hj+Hint.

[0008] Next, as shown in drawing 24 , an example of an approach which manufactures the spin bulb mold magneto-resistive effect component of the laminating ferry PINDO structure which divided the fixed magnetic layer to the 1st fixed magnetic layer 111 and the 2nd fixed magnetic layer 112 is explained below with reference to drawing 25 . In drawing 25 , only the antiferromagnetism layer 110, the 1st fixed magnetic layer 111, the 2nd fixed magnetic layer 112, and the free magnetic layer 113 are shown for simplification of explanation. While omitting and indicating the nonmagnetic interlayer prepared between the 1st fixed magnetic layer 111 and the 2nd fixed magnetic layer 112 The simple laminated structure at the time of omitting the nonmagnetic conductive layer prepared between the 2nd fixed magnetic layer 112 and the free magnetic layer 113, indicating, shifting the location of each class by which the laminating was carried out, and making the sense of magnetization of each class legible is shown. In addition, in the structure shown in drawing 24 , magnetic thickness (value which integrated thickness to the intensity of magnetization of a fixed magnetic layer) of the 1st fixed magnetic layer 111 shall be made smaller than the magnetic thickness of the 2nd fixed magnetic layer 112.

[0009] In order to manufacture the spin bulb mold magneto-resistive effect component shown in drawing 24 To the 1st The free magnetic layer 113 which consists of the 2nd fixed magnetic layer 112 which consists of the 1st fixed magnetic layer 111 which consists of an antiferromagnetism layer 110 which consists of PtMn etc. as shown on a substrate at drawing 25 , Co, etc., a nonmagnetic interlayer of illustration abbreviation, Co, etc., a nonmagnetic conductive layer of illustration abbreviation, NiFe, etc. In case the layered product to provide is formed, the 1st fixed magnetic layer 111 and the 2nd fixed magnetic layer 112 are formed impressing a field in the truck cross direction and the direction of a right angle, a nonmagnetic conductive layer is formed next, and the free magnetic layer 113 is formed, impressing a field crosswise [truck] further. It can consider as the condition of having made the sense of the magnetic anisotropy of the fixed magnetic layers 111 and 112 and the free magnetic layer 113 by this crossing 90 degrees as shown in drawing 25 A.

[0010] Next, the annealing field H100 which intersects perpendicularly heat treatment for making the antiferromagnetism layer 110 of PtMn into ordered structure crosswise [truck] as shown in drawing 25 B "for example It comes to make a strong switched connection field (exchange anisotropy field) act by carrying out making 400 or more kA/m" impress according to the interface of the antiferromagnetism layer 110 of PtMn, and the 1st fixed magnetic layer 111. While the sense of magnetization of the 1st fixed magnetic layer 111 is fixable in the direction of the annealing field H100 which intersects perpendicularly crosswise [truck] After annealing field removal, the direction of magnetization of the 2nd fixed magnetic layer 112 can be turned to an opposite direction 180 degrees with the annealing field H100 by the switched connection field (RKKY interaction) generated between the 1st fixed magnetic layer 111 and the 2nd fixed magnetic layer 112, and it can fix. Moreover, it gathers in the direction which intersects perpendicularly with the truck cross direction as the sense of the magnetic anisotropy of the free magnetic layer 113 shows drawing 25 B by performing annealing in this magnetic field.

[0011] Next, annealing in a magnetic field can be perform impress a field H200 (facing the right or facing the left be sufficient as a direction in drawing 25 C) crosswise [truck], as show in drawing 25 C, and the spin bulb mold magneto-resistive effect component in the condition of having make the sense of the magnetic anisotropy of the fixed magnetic layers 111 and 112 and the free magnetic layer 113 intersect 90 degrees as show in drawing 25 C can be obtain by turn the direction of the uniaxial anisotropy of the free magnetic layer 113 so that a field H200 may be meet.

[0012]

[Problem(s) to be Solved by the Invention] by the way, by having prepared one sheet, the fixed magnetic layer 103 like the structure shown in drawing 23 enlarging the pinning force in which the anti-field in a component edge is

large, the leakage field to the exterior is large, and it may be made to act from the antiferromagnetism layer 102 to the fixed magnetic layer 103 -- being hard -- since -- As shown in drawing 24 R> 4, the spin bulb mold magneto-resistive effect component of the laminating ferry PINDO structure constituted so that the reverse sense might be made mutually magnetized for every layer was developed by making a fixed magnetic layer into two-layer structure. The structure shown in drawing 24 is constituted so that the sense of magnetization of the 1st fixed magnetic layer 111 and the 2nd fixed magnetic layer 112 may become anti-parallel, makes a magnetic joint field act on the fixed magnetic layer of two-layer structure efficiently from the antiferromagnetism layer 110, and enables it to acquire the powerful pinning force by making the magnetic moment of one fixed magnetic layer larger than the magnetic moment of the fixed magnetic layer of another side.

[0013] If it is in the spin bulb mold magneto-resistive effect component of the laminating ferry PINDO structure shown in drawing 24 While effect of the anti-field (dipole field) Hd which affects the free magnetic layer 113 can be made small by negating most leakage fields of a two-layer fixed magnetic layer by the leakage field of the 1st fixed magnetic layer If it sees from the field of the above-mentioned asymmetry, since the anti-field Hd will become small By negating the anti-field Hd by the detection current field Hj, the device which was going to adjust asymmetry stopped being materialized easily and it had the problem with which the force of the detection current field Hj is too strong, and it becomes impossible that it is hard to double asymmetry conversely. When the anti-field Hd becomes small in the case of the laminated structure especially shown in drawing 24 , effect arises in the sense of magnetization of the free magnetic layer 105 by the detection current field Hj, it inclines in the sense which the sense of magnetization of the free magnetic layer 105 inclines in the lower right sense in drawing 24 R> 4, and is shown by agreement Mf1, and there are the fixed magnetic layer 111 and a problem from which the sense of magnetization of 112 stops being in a crossover condition 90 degrees.

[0014] Moreover, the anti-field Hd was enlarged suitably, the detection current field Hj was balanced, and although it was also considered that it is going to adjust asymmetry, since the pinning force in which the antiferromagnetism layer 110 makes it act on the pinning layers 111 and 112 conversely declines, in order to adjust asymmetry in the spin bulb mold magneto-resistive effect component of laminating ferry PINDO structure, other controlling mechanisms needed to be examined.

[0015] Next, if it is in the thin film magnetic head equipped with the spin bulb mold magneto-resistive effect component, it is common to consider as a compound configuration with the write head which was equipped with the magneto-resistive effect mold component upwards as a read-out component, and was equipped with the inductive component (magnetic-induction mold head) as a write-in component. This write head has an induction type coil for record, and although it consists of preparing the magnetic pole and magnetic gap for the store formed in the tip side of this induction type coil with the magnetic film, in order to insulate an induction type coil from other layers, it needs to prepare the insulating layer of resin. When forming the insulating layer of wrap resin for this induction type coil, it is made to harden by heat-treating, after applying non-hardened resin conventionally. Therefore, as shown in drawing 25 C, after giving the uniaxial anisotropy of the free magnetic layer 113 in the production process shown in drawing 25 , the formation process of the write head is performed. Subsequently, although it will heat-treat after being accompanied by the up shielding 114 and the lower shielding 115 of a magneto-resistive effect component which are prepared respectively up and down Since the heat treatment temperature for resin hardening performed here turns into high temperature exceeding 473K (200 degrees C) As shown in drawing 25 E, there was a possibility that it might become impossible for the uniaxial anisotropy of the free magnetic layer 113 to demonstrate the engine performance of the purpose as a read-out component, such as leading to generating of a Barkhausen noise, by heat treatment since turbulence and anisotropy distribution arise.

[0016] Moreover, although considering up shielding 114 prepared in the upper part side of a magneto-resistive effect component in the thin film magnetic head as the configuration which serves as the lower core layer of the write head (inductive head) is generally performed If turbulence is produced in turbulence and coincidence of the uniaxial anisotropy of said free magnetic layer 113 at the direction of the easy axis of the up shielding layer 114 itself when the up shielding 114 is used also [core layer / lower] Whenever an inductive head records magnetic information on a magnetic-recording medium, the magnetization condition of the up shielding layer 114, That is, the magnetic-domain structure of the up shielding layer 114 changed to the ** irreversible target, and there was a possibility that playback outputting [of a magneto-resistive effect component] might become unstable with the instability of the field which the irreversible magnetic domain generates.

[0017] This invention aims at offering the thin film magnetic head using the spin bulb mold magneto-resistive effect component which it is and aimed at reduction in asymmetry especially by adjusting the sense of magnetization of a fixed magnetic layer and a free magnetic layer so that it may become the regular sense in the condition that the detection current field acted and this spin bulb mold magneto-resistive effect component for solving said conventional trouble. This invention is for solving the trouble of said conventional approach, and makes one of the purposes offer of the spin bulb mold magneto-resistive effect component of the laminating ferry PINDO structure where reduction of above-mentioned asymmetry can be aimed at, and the thin film magnetic head

equipped with it, and offer of the approach of manufacturing these spin bulb mold magneto-resistive effect component and the thin film magnetic head. Furthermore, the manufacture approach of this invention aims at offer of the approach of manufacturing the spin bulb mold magneto-resistive effect component which aimed at reduction in asymmetry by adjusting the direction of the impression field in the case of magnetizing each class according to the relation of the magnetic thickness of the 1st fixed magnetic layer and the 2nd fixed magnetic layer.

[0018]

[Means for Solving the Problem] This invention is formed in contact with an antiferromagnetism layer and this antiferromagnetism layer. By the exchange anisotropy field with said antiferromagnetism layer The 1st fixed magnetic layer to which the magnetization direction was fixed, and the 2nd fixed magnetic layer by which it was formed in said 1st fixed magnetic layer through the nonmagnetic interlayer, and the magnetization direction was arranged with the magnetization direction of said 1st fixed magnetic layer, and anti-parallel, The free magnetic layer formed in this 2nd fixed magnetic layer through the nonmagnetic conductive layer, The vertical bias layer which impresses a field crosswise [truck] to said free magnetic layer, It is the spin bulb mold magneto-resistive effect component equipped with said 2nd fixed magnetic layer, the nonmagnetic conductive layer, and the lead layer of the pair which gives a detection current to a free magnetic layer. Where the detection current from said lead layer is supplied, the magnetization direction of said free magnetic layer is arranged in the magnetization direction of said 2nd fixed magnetic layer, and the crossing direction. It is characterized by the magnetization direction of said 2nd fixed magnetic layer coming to incline at an include angle theta in the direction which keeps away from a vertical bias field to the truck cross direction and a perpendicular direction. In the condition that the detection current field acted, since the direction of magnetization of a free magnetic layer crosses at an angle of the direction of magnetization of a fixed magnetic layer, and a convention, when the magnetic information on a magnetic-recording medium is read and an output is obtained, it becomes possible to decrease asymmetry.

[0019] This invention is formed in contact with an antiferromagnetism layer and this antiferromagnetism layer. By the exchange anisotropy field with said antiferromagnetism layer The 1st fixed magnetic layer to which the magnetization direction was fixed, and the 2nd fixed magnetic layer by which it was formed in said 1st fixed magnetic layer through the nonmagnetic interlayer, and the magnetization direction was arranged with the magnetization direction of said 1st fixed magnetic layer, and anti-parallel, The free magnetic layer formed in this 2nd fixed magnetic layer through the nonmagnetic conductive layer, The vertical bias layer which impresses a field crosswise [truck] to said free magnetic layer, It is the spin bulb mold magneto-resistive effect component equipped with said 2nd fixed magnetic layer, the nonmagnetic conductive layer, and the lead layer of the pair which gives a detection current to a free magnetic layer. Where the detection current from said lead layer is supplied, the magnetization direction of said free magnetic layer is arranged in the magnetization direction of said 2nd fixed magnetic layer, and the crossing direction. It is characterized by the magnetization direction of said free magnetic layer coming to incline at an include angle theta towards the magnetization direction of said 2nd fixed magnetic layer to the truck cross direction. In the condition that the detection current field acted, since the direction of magnetization of a free magnetic layer intersects the direction of magnetization of a fixed magnetic layer, when magnetic information is read and an output is obtained, it becomes possible to decrease asymmetry.

[0020] In this invention, it is desirable that said include angles theta are 2 times or more and 30 degrees or less, it is more desirable that said include angles theta are 3 times or more and 15 degrees or less, and it is most desirable that said include angles theta are 3 times or more and 10 degrees or less. If it is these include-angle range, it will become possible to decrease asymmetry further, without reducing a playback output. If said include angle is too large, an output will decline, and if too small, the improvement effect of asymmetry will become is hard to be acquired.

[0021] In this invention, it is desirable that it is characterized by coming to make the include angle of the magnetization direction of said free magnetic layer and the magnetization direction of said 2nd fixed magnetic layer to make into 90 degrees in the condition that said detection current is supplied and the external magnetic field is not impressed. Although the direction of magnetization of a free magnetic layer inclines in response to effect according to an operation of the detection current field by the detection current, since the direction of magnetization of a fixed magnetic layer and the direction of magnetization of a free magnetic layer intersect perpendicularly in this inclination condition, the high playback output was obtained upwards and asymmetry can be lessened most.

[0022] When the product of saturation magnetization Ms and Thickness t is made into magnetic thickness in this invention, The relation of the magnetic thickness of the 2nd fixed magnetic layer is satisfied. the magnetic thickness of the 1st fixed magnetic layer -- < -- And it is desirable to come to make into the 2nd magnetization direction and reverse sense of a fixed magnetic layer the direction of a detection current field where the direction of the detection current field which acts on a free magnetic layer acts on the magnetization direction of the 2nd fixed magnetic layer and the reverse sense, i.e., the 2nd fixed magnetic layer.

[0023] In this invention, said antiferromagnetism layer is formed with a XMn alloy or a XMnX' alloy, and, as for X, it is [any one sort of Pt, Pd, Rh, Ir, Ru, and the Os or two sorts or more, and X'] desirable to consist of any one

sort of Au, Ag, Cr, nickel, Ne, Ar, Xe, and the Kr or two sorts or more. If it is the antiferromagnetism layer which consists of these alloy ingredients, since blocking temperature is high compared with the conventional antiferromagnetism ingredients, such as FeMn, the spin bulb mold magneto-resistive effect component stabilized thermally can be obtained.

[0024] In this invention, it is desirable to come to make into 96 or more kA/m the synthetic exchange anisotropy field which said antiferromagnetism layer makes act to the laminating mold fixed magnetic layer possessing said 1st fixed magnetic layer and said nonmagnetic interlayer, and said 2nd fixed magnetic layer. A possibility that the inclination of magnetization may become unusual in the periphery part of a fixed magnetic layer by the hard bias field received from a vertical bias layer as a synthetic switched connection field is a value high in this way decreases.

[0025] In this invention, it is desirable to come to carry out the laminating of said antiferromagnetism layer, the 1st fixed magnetic layer, a nonmagnetic interlayer, the 2nd fixed magnetic layer, a nonmagnetic conductive layer, and the free magnetic layer on a substrate. If it is in the so-called bottom type which carried out the laminating of the antiferromagnetism layer to the side near a substrate of spin bulb mold magneto-resistive effect component <DP N=0008>, magnitude of the exchange anisotropy field of a fixed magnetic layer can be enlarged.

[0026] In this invention, it can consider as the structure of coming to divide said free magnetic layer into the 1st free magnetic layer and the 2nd free magnetic layer through a conductive interlayer. In this invention, the structure of coming to carry out the laminating of said free magnetic layer and nonmagnetic conductive layer, the 2nd fixed magnetic layer, a conductive interlayer, the 1st fixed magnetic layer, and the antiferromagnetism layer is employable on a substrate.

[0027] It is characterized by the thin film magnetic head concerning this invention coming to prepare the spin bulb mold magneto-resistive effect component of a publication for either of previous as a magnetic information read-out component.

[0028] At least the manufacture approach of this invention on a substrate An antiferromagnetism layer and the 1st fixed magnetic layer, When the layered product equipped with a nonmagnetic interlayer, the 2nd fixed magnetic layer, the nonmagnetic conductive layer, and the free magnetic layer is formed, The process which forms membranes, impressing the 1st field to the 1st direction of the truck cross direction, or its 180-degree opposite direction at the time of said free magnetic layer membrane formation, and gives uniaxial anisotropy crosswise [truck] to said free magnetic layer, Impressing the 2nd field in the 2nd direction of which the include-angle theta inclination was done to the direction which intersects perpendicularly with the truck cross direction at said layered product, or its 3rd direction of a 180-degree opposite direction Heat-treat with the 1st heat treatment temperature, and the interface of said antiferromagnetism layer and said 1st fixed magnetic layer is made to generate an exchange anisotropy field. As opposed to the direction which intersects perpendicularly magnetization of said 1st fixed magnetic layer, and magnetization of the 2nd fixed magnetic layer with said truck cross direction an include-angle theta inclination The process which is the direction carried out and is mutually fixed to 180-degree opposite sense, The process which forms the vertical bias layer for impressing a bias field to said free magnetic layer in the both sides of said layered product, The process which performs 2nd heat treatment with the 2nd heat treatment temperature, impressing the 3rd field to said free magnetic layer in the 1st direction of the truck cross direction, or its 180-degree opposite direction, and gives uniaxial anisotropy again to said free magnetic layer, It is characterized by providing the process which impresses the 4th field in the 4th direction opposite to the sense of the vector component of the truck cross direction of magnetization of said 2nd fixed magnetic layer, and magnetizes said vertical bias layer.

[0029] The field of the 1st fixed magnetic layer of the side which touches an antiferromagnetism layer is fixable in the state of the inclination of an include angle theta by impressing the 2nd field in the 2nd direction and heat-treating it with the 1st heat treatment temperature. And the spin bulb mold magneto-resistive effect component which the sense [magnetic layer / a fixed magnetic layer and / free] of magnetization intersects in the condition that the detection current field acted, by arranging the sense of the uniaxial anisotropy of a free magnetic layer crosswise [truck] next can be obtained.

[0030] In this invention, the value which integrated thickness to the magnetic moment of each of said fixed magnetic layer is made into magnetic thickness. Magnetic thickness of said 1st fixed magnetic layer is made larger than the magnetic thickness of said 2nd fixed magnetic layer. When said 2nd field is carried out in 400kA/m or more, the direction of magnetization of said 1st fixed magnetic layer is turned in the direction which impresses said 2nd field. While turning the direction of magnetization of said 2nd fixed magnetic layer in the 3rd direction opposite 180 degrees, said 2nd field by considering as the range of 8-80kA/m The direction of magnetization of said 1st fixed magnetic layer can be turned in the 2nd direction which impresses said 2nd field, and the direction of magnetization of said 2nd fixed magnetic layer can be turned in the 3rd direction opposite to said 2nd direction.

[0031] In this invention, the value which integrated thickness to the magnetic moment of each of said fixed magnetic layer is made into magnetic thickness. Magnetic thickness of said 1st fixed magnetic layer is made

smaller than the magnetic thickness of the 2nd fixed magnetic layer. When said 2nd field is carried out in 400kA/m or more, the direction of magnetization of said 1st fixed magnetic layer is turned in the direction which impresses said 2nd field. The direction of magnetization of said 2nd fixed magnetic layer can be turned in the 3rd direction opposite 180 degrees. moreover, the thing for which making said 2nd field into the range of 8 - 80 kA/m also turns the direction which impresses said 2nd field, and the direction of the magnetization of said 1st fixed magnetic layer to a 180-degree opposite direction, and the direction of magnetization of said 2nd fixed magnetic layer is turned in the direction which impresses said 2nd field -- things are made.

[0032] In this invention, the heat treatment process for forming the induction type magnetic head for record on said layered product between said 1st heat treatment and the 2nd heat treatment can be performed. Although the directivity of the uniaxial anisotropy of a free magnetic layer is once confused according to the heat treatment process for forming the induction type magnetic head for record, since the direction of the uniaxial anisotropy of a free magnetic layer is arranged by 2nd heat treatment performed behind, the spin bulb mold magneto-resistive effect component which finally arranged the sense of the uniaxial anisotropy of a free magnetic layer can be obtained.

[0033] In this invention, the process which impresses the 1st field to said free magnetic layer in the 1st direction of the truck cross direction or its 180-degree opposite direction, and gives uniaxial anisotropy crosswise [truck] to a free magnetic layer before the process which forms said induction type magnetic head for record can be performed. In this invention, it can be made smaller than the 2nd field which performs the 3rd field impressed in said 2nd heat treatment in said 1st heat treatment. By making the 3rd field smaller than the 2nd field, the direction of the uniaxial anisotropy of a free magnetic layer can be arranged, without doing a bad influence towards magnetization of the fixed magnetic layer given previously.

[0034] In this invention, the 3rd field impressed in said 2nd heat treatment is made in 8kA [m] /or more and m and 40kA /or less. In this invention, while making said 1st heat treatment temperature below into 553K (280 degrees C) more than 503K (230 degrees C), said 2nd heat treatment temperature can be made below into 513K (240 degrees C) more than 433K (160 degrees C). In this invention, said antiferromagnetism layer can be formed with a XMn alloy or a XMnX' alloy, and any one sort of Pt, Pd, Rh, Ir, Ru, and the Os or two sorts or more, and X' can be made into any one sort of Au, Ag, Cr, nickel, Ne, Ar, Xe, and the Kr, or two sorts or more for X.

[0035] The manufacture approach of this invention is applicable to the configuration which has arranged said antiferromagnetism layer between a substrate and a free magnetic layer as said layered product.

[0036] At least this invention on a substrate An antiferromagnetism layer and the 1st fixed magnetic layer, In case the layered product equipped with a nonmagnetic interlayer, the 2nd fixed magnetic layer, the nonmagnetic conductive layer, and the free magnetic layer is formed The process which forms membranes, impressing the 1st field to said free magnetic layer in the 1st direction of the truck cross direction, or its 180-degree opposite direction, and gives uniaxial anisotropy crosswise [truck] to said free magnetic layer, Impressing the 2nd field in the direction which intersects perpendicularly with the truck cross direction at said layered product The process which heat-treat with the 1st heat treatment temperature, and the interface of said antiferromagnetism layer and said 1st fixed magnetic layer is made to generate an exchange anisotropy field, and fixes the magnetization direction of said 1st fixed magnetic layer and the 2nd fixed magnetic layer in the direction which intersects perpendicularly with the truck cross direction, The process which forms the vertical bias layer for impressing a bias field to said free magnetic layer in the both sides of said layered product, It heat-treats with the 2nd heat treatment temperature, impressing the 3rd field to said free magnetic layer in the 1st direction or said 1st direction, and 180-degree opposite direction of the truck cross direction. As opposed to the direction which intersects perpendicularly the magnetization direction of said 1st fixed magnetic layer and the 2nd fixed magnetic layer crosswise [said / truck] while giving uniaxial anisotropy again to said free magnetic layer an include-angle theta inclination The process fixed in the direction carried out, It is characterized by providing the process which impresses the 4th field in the direction opposite to the sense of the vector component of the truck cross direction of magnetization of said 2nd fixed magnetic layer, and magnetizes said vertical bias layer.

[0037] The magnetization of the 1st near fixed magnetic layer and the magnetization of the 2nd fixed magnetic layer which touch an antiferromagnetism layer are fixable in the direction which intersects perpendicularly crosswise [truck] by impressing the 2nd field in the 2nd direction and heat-treating it with the 1st heat treatment temperature. And the include-angle theta inclination of the sense of magnetization of a fixed magnetic layer can be done by heat-treating impressing a field crosswise [truck] next to the direction which intersects perpendicularly crosswise [truck], and the spin bulb mold magneto-resistive effect component which the sense [magnetic layer / a fixed magnetic layer and / free] of magnetization intersects in the condition that the detection current field acted can be obtained.

[0038] In this invention approach, the value which integrated thickness to the magnetic moment of each of said fixed magnetic layer is made into magnetic thickness. Magnetic thickness of said 1st fixed magnetic layer is made larger than the magnetic thickness of said 2nd fixed magnetic layer. When said 2nd field is made into 400 or more

kA/m, the direction of magnetization of said 1st fixed magnetic layer can be turned in the direction which impresses said 2nd field, and the direction of magnetization of said 2nd fixed magnetic layer can be turned in the 3rd direction opposite 180 degrees. Or making said 2nd field into the range of 8 - 80 kA/m can also turn the direction of magnetization of said 1st fixed magnetic layer in the 2nd direction which impresses said 2nd field, and it can turn the direction of magnetization of said 2nd fixed magnetic layer in the 3rd direction opposite to said 2nd direction.

[0039] In this invention approach, the value which integrated thickness to the magnetic moment of each of said fixed magnetic layer is made into magnetic thickness. Magnetic thickness of said 1st fixed magnetic layer is made smaller than the magnetic thickness of the 2nd fixed magnetic layer. When said 2nd field is carried out in 400kA/m or more, the direction of magnetization of said 1st fixed magnetic layer is turned in the direction which impresses said 2nd field. The direction of magnetization of said 2nd fixed magnetic layer is turned in the 3rd direction opposite 180 degrees. Making said 2nd field into the range of 8-80kA/m can also turn the direction which impresses said 2nd field, and the direction of the magnetization of said 1st fixed magnetic layer to a 180-degree opposite direction, and the direction of magnetization of said 2nd fixed magnetic layer can be turned in the direction which impresses said 2nd field.

[0040] In this invention, it can have a heat treatment process for forming the induction type magnetic head for record on said layered product between said 1st heat treatment and the 2nd heat treatment. By having a heat treatment process for forming the induction type magnetic head for record, although the directivity of the uniaxial anisotropy of a free magnetic layer is once confused, since the sense of the uniaxial anisotropy of a free magnetic layer is arranged by 2nd heat treatment which impresses a field crosswise [truck] after that, finally the direction of the uniaxial anisotropy of a free magnetic layer can be arranged.

[0041] In this invention, said 2nd heat treatment temperature can be made below into 513K (240 degrees C) more than 433K (160 degrees C), and 1st heat treatment temperature can be made below into 553K (280 degrees C) more than 503K (230 degrees C).

[0042] In this invention, said antiferromagnetism layer can be formed with a XMn alloy or a XMnX' alloy, and any one sort of Pt, Pd, Rh, Ir, Ru, and the Os or two sorts or more, and X' can be made into any one sort of Au, Ag, Cr, nickel, Ne, Ar, Xe, and the Kr, or two sorts or more for X.

[0043] In this invention, it can consider as the configuration which has arranged said antiferromagnetism layer between a substrate and a free magnetic layer as said layered product.

[0044] In this invention, it has the process which enforces the manufacture approach of the spin bulb mold magneto-resistive effect component a publication to either of previous, and forms the magneto-resistive effect mold component as a read-out component in it, and a process for forming the induction type magnetic head for record on said layered product, and the thin film magnetic head can be manufactured.

[0045]

[Embodiment of the Invention] "1st operation gestalt" drawing 1 - drawing 3 are drawings showing an example of the spin bulb mold magneto-resistive effect component with which the thin film magnetic head of the 1st operation gestalt of this invention is equipped. The structure shown in drawing 1 R> 1 - drawing 3 is structure prepared in the thin film magnetic head of the surfacing transit type illustrated to drawing 4 - drawing 6 , and the thin film magnetic head 150 of this example is carried in magnetic recording media, such as a hard disk drive unit.

[0046] The side shown with a sign 155 in drawing 4 is a leading side suitable for the upstream of the migration direction of a disk side, and the slider 151 of the thin film magnetic head 150 of this example is the trailing side by which the side shown with a sign 156 turns to the downstream. In the field which counters the magnetic disk of the slider 151 of this example, the rail-like ABS sides (pneumatic-bearing side: surfacing side of the rail section) 151a, 151a, and 151b and the Ayr grooves 151c and 151c of a ditch type are formed. In addition, the slider 151 of this example consists of non-magnetic material which consists of ceramics, such as aluminum2O3-TiC, etc. And the magnetic-core section 157 is formed in 151d of end faces by the side of trailing of this slider 151.

[0047] In this example, the magnetic-core section 157 of the thin film magnetic head is the compound-die magnetic-core structure of the cross-section structure shown in drawing 5 and drawing 6 , and on 151d of trailing side edge sides of a slider 151, the laminating of a read head (GMR head using a spin bulb mold magneto-resistive effect component) h1 and the induction type magnetic head h2 for record (inductive head) is carried out, and it is constituted.

[0048] If it is in GMR head h1 of this example, the lower gap layer 164 which consists of insulators, such as an alumina (aluminum 2O3), is formed on the lower shielding layer 163 which consists of a magnetic alloy on the protective layer 162 which consists of insulators, such as an alumina (aluminum 2O3) formed in the trailing side edge section of a slider 151, first. And the laminating of the spin bulb mold magneto-resistive effect component GMR 1 is carried out to the ABS side 151b side on the lower gap layer 164. The up gap layer 166 is formed on this magneto-resistive effect component GMR 1 and said lower gap layer 164, and the up shielding layer 167 is formed on it. Besides, let the section shielding layer 167 at combination be the lower core layer of the inductive head

(induction type write head) h2 formed on it.
[0049] Next, the induction coil 176 patternized so that the gap layer 174 might be formed on the lower core layer 167 used as said up shielding layer 167 at combination and an inductive head h2 might become spiral superficially on it is formed. Said induction coil 176 is surrounded by the insulating material layer 177 which consists of resin etc. The up core layer 178 formed on the insulating material layer 177 opens a minute gap in the lower core layer 167 for point 178a which constitutes the pole tip in ABS side 151b, constitutes magnetic gap WG for a store, counters, connects end face section 178b to the lower core layer 167 magnetically, and is prepared. Moreover, on the up core layer 178, the protective layer 179 which consists of an alumina etc. is formed.
[0050] GMR head h1 of the above-mentioned structure reads the contents of record of a magnetic-recording medium by changing resistance of the spin bulb mold magneto-resistive effect component GMR 1, and reading this resistance change by the existence of the minute leakage field from magnetic-recording media, such as a disk of a hard disk.
[0051] Next, in the inductive head h2 of the above-mentioned structure, a record current is given to a coil 176 and a record current is given to a core layer from a coil 176. And an inductive head h2 records a magnetic signal on magnetic-recording media, such as a hard disk, by the leakage field from the point of the lower core layer 167 in the part of magnetic gap WG, and the up core layer 178.
[0052] Although the whole thin film magnetic-head 150 structure was explained so far, the magneto-resistive effect mold (spin bulb mold) thin film GMR 1 which is the important section of this invention is explained in full detail based on drawing 1 - drawing 3 below. The migration direction of magnetic-recording media, such as a hard disk, is a Z direction of drawing 1 and drawing 2 , and the directions of the leak field from a magnetic-recording medium are drawing 1 and the direction of Y of drawing 2 .
[0053] In the structure of this operation gestalt, the spin bulb mold magneto-resistive effect component GMR 1 is formed on the lower gap layer 164 on a slider 151. Drawing 1 - drawing 3 are what shows the 1st operation gestalt of the magneto-resistive effect component of the spin bulb mold concerning this invention. On the lower gap layer 164, the laminating of the antiferromagnetism layer 1, the fixed magnetic layer 2, the nonmagnetic conductive layer 3, the free magnetic layer 4, and the protective layer 5 is carried out one by one by the width of face approximated to the width of recording track Tw. The cross-section isosceles trapezoid-like layered product 6 is formed of these, the vertical bias layer 7 which consists of a hard magnetic material of the configuration which touches the truck cross direction both sides of a layered product 6 in both the inclined planes of a layered product 6 is formed, and the laminating of the current lead layer 8 is carried out on each vertical bias layer 7. Moreover, in the structure of this operation gestalt, it considers as the so-called synthetic ferry PINDO mold (Synthetic-ferri-pinned type) with which the fixed magnetic layer 2 was divided through the nonmagnetic interlayer 10 by the 1st fixed magnetic layer 11 by the side of the antiferromagnetism layer 1, and the 2nd fixed magnetic layer 12 by the side of the nonmagnetic conductive layer 3. Furthermore, in the structure of this gestalt, the free magnetic layer 4 consists of a 1st free magnetic layer 13 by the side of the nonmagnetic conductive layer 3, and a 2nd free magnetic layer 14 by the side of a protective layer 5.
[0054] As for said antiferromagnetism layer 1, it is desirable to be formed with the PtMn alloy of ordered structure or the XMn alloy of ordered structure, and the PtMnX' alloy. Compared with a NiMn alloy, a FeMn alloy, etc. which are used as an antiferromagnetism layer from the former, it excels in corrosion resistance, and moreover, the PtMn alloy of ordered structure has high blocking temperature, and its switched connection field (exchange anisotropy field) is also large. Moreover, in this invention, it replaces with said PtMn alloy and may be formed with the XMn (however, X is one-sort [any] or two sorts or more of elements of Pd, Ir, Rh, and Ru) alloy, or the PtMnX'(however, X' is one-sort [any] or two sorts or more of elements of Pd, Ir, Rh, Ru, Au, and Ag) alloy. The nonmagnetic interlayer 10 who intervenes between the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 is formed for said 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 with 1 sorts or two sorts or more of alloys among Ru, Rh, Ir, Cr, Re, and Cu while being formed with Co, the NiFe alloy, the CoNiFe alloy, the CoFe alloy, etc.
[0055] By the way, the arrow head shown in the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 which are shown in drawing 1 - drawing 3 expresses the direction of each magnetic moment, and the magnitude (magnetic thickness) of said magnetic moment is determined with the value to which saturation magnetization (Ms) and thickness (t) were applied. Since it is formed according to the quality of the material with same said 1st fixed magnetic layer 11 and 2nd fixed magnetic layer 12, for example, Co film, and the thickness tP2 of the 2nd fixed magnetic layer 12 is moreover formed more greatly than the thickness tP1 of the 1st fixed magnetic layer 11, compared with the 1st fixed magnetic layer 11, the magnetic moment is enlarged for the direction of the 2nd fixed magnetic layer 12. A paraphrase enlarges magnetic thickness for the direction of the 2nd fixed magnetic layer 12 compared with the 1st fixed magnetic layer 11. In addition, in this invention, it needs to have the magnetic thickness from which the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 differ, therefore the thickness tP1 of the 1st fixed magnetic layer 11 may be formed more thickly than the thickness tP2 of the 2nd fixed

magnetic layer 12.
[0056] From such a background, the thickness of the 1st fixed magnetic layer 11 has the desirable range of 1-7nm, the thickness of the 2nd fixed magnetic layer 12 has the desirable range of 1-7nm, as for both thickness difference, it is desirable that it is 0.2nm or more, and it is desirable that it is below 10nm (10A). Moreover, the nonmagnetic interlayer's 10 thickness has the desirable range of 0.5-1nm. Since resistance rate of change falls remarkably while component resistance will become large too much if preferably less than the aforementioned range since splitting of the conduction electron which is not contributed to a magneto-resistive effect will increase and resistance rate of change will fall if the thickness of said 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 exceeds the aforementioned range, it is not desirable. In addition, the arrow head shown in drawing 1 R> 1 and drawing 2 about the size of the magnetic moment has an inclination component to the space of each drawing, and since the arrow head shown in drawing 1 and drawing 2 does not necessarily express contrast of the magnitude of each magnetic moment correctly, it explains it in full detail behind based on drawing 3 also about the direction of the magnetic moment of each class while explaining the magnetic moment of each class in full detail behind based on drawing 3 .
[0057] As shown in drawing 1 and 2, the free magnetic layer 4 is formed by two-layer, and the 1st free layer 13 formed in the side which touches said nonmagnetic conductive layer 3 is formed by Co film. Moreover, the 2nd free layer 14 is formed with the NiFe alloy, a CoFe alloy or a CoNiFe alloy, etc. In addition, the reason for forming the 1st free layer 13 of Co in the side which touches the nonmagnetic conductive layer 3 is that diffusion of the metallic element in an interface with said nonmagnetic conductive layer 3 formed of Cu etc. can be prevented, and it can enlarge **R/R (resistance rate of change).
[0058] If this is in the giant magneto-resistance developmental mechanics of the structure which sandwiches the nonmagnetic conductive layer 3 by the ferromagnetic fixed magnetic layer 2 and the ferromagnetic free magnetic layer 4 The effectiveness of spin dependence dispersion of conduction electron is large at the interface of Co and Cu, And possibility that factors other than spin dependence dispersion of conduction electron will arise is low, and it originates in the ability of a higher magneto-resistive effect to be acquired rather than the direction constituted from an ingredient of the same kind constitutes the fixed magnetic layer 2 and the free magnetic layer 4 from an ingredient of a different kind. Since it is such, when the 2nd fixed magnetic layer 12 is constituted from Co, the structure which used the 1st free layer 13 by the side of the nonmagnetic conductive layer 3 as Co layer by predetermined thickness in the free magnetic layer 4 is desirable. Moreover, even if distinguish especially Co layer and it does not prepare it like this operation gestalt, it is good also as an alloy layer of a concentration gradient to which Co concentration becomes thin gradually as it considers as the alloy condition in which there is much Co and the nonmagnetic conductive layer 3 side was included by making the free magnetic layer 4 into monolayer structure and goes to a protective layer 5 side. Moreover, as for said protective layer 5, it is desirable to consist of a metallic material which was excellent in stable oxidation resistance with elevated temperatures, such as Ta.
[0059] On the other hand, the vertical bias layer 7 shown in drawing 2 consists of hard magnetism (hard) ingredients, such as a CoPt alloy or a CoCrPt alloy, and the current lead layer 8 consists of electrical conducting materials, such as Au, Ta, W, or Cr. Said vertical bias layer 7 is for arranging in the direction as a bias field is made to act on said free magnetic layer 4 and shows the sense of magnetization of the free magnetic layer 4 to the arrow head of drawing 1 - drawing 3 , and single-domain-izing the free magnetic layer 4.
[0060] Next, the magnetization direction of the 1st fixed magnetic layer 11, the magnetization direction of the 2nd fixed magnetic layer 12, the magnetization direction of the free magnetic layer 4, and the direction of a detection current field are explained in full detail based on drawing 3 . As shown in drawing 3 , the direction of magnetization of the 1st fixed magnetic layer 11 and the direction of magnetization of the 2nd fixed magnetic layer 12 are made into an anti-parallel condition (ferrimagnetism condition) different 180 degrees, but in the condition of having passed the detection current J, it is turned so that the sense of magnetization of the free magnetic layer 4 may intersect 90 degrees to the fixed magnetic layer 11 and the sense of magnetization of 12. Although this condition is clearly shown in drawing 3 , the vector which shows the sense of magnetization in drawing 1 and drawing 2 has an inclination component to the longitudinal direction (X1 direction) of space, and shows only the vector component of the sense parallel to space in drawing 1 and drawing 2 . Therefore, although drawn in drawing 1 and drawing 2 by the arrow head which shows a vector that magnetization of the fixed magnetic layers 11 and 12 and magnetization of the free magnetic layer 4 do not lie at right angles, the actual rectangular condition of the vector of magnetization of each class is set up as clearly shown in drawing 3 . In addition, although the explanatory view at the time of making it, as for drawing 3 A, the detection current J flow on left-hand side from right-hand side and drawing 3 B are the explanatory views at the time of making it the detection current J flow on right-hand side from left-hand side, in the case of which, the magnetization direction of the fixed magnetic layers 11 and 12 and the magnetization direction of the free magnetic layer 4 are made into a rectangular condition about 90 degrees, and show the equivalent condition.
[0061] In the condition that the detection current (sense current) J from said current lead layer 8 was supplied so

that clearly from drawing 3 A The magnetization direction of said free magnetic layer 4 is arranged in the magnetization direction of said 2nd fixed magnetic layer 12, and the crossing direction. The direction of the magnetization Mp2 of said 2nd fixed magnetic layer 12 inclines at the include angle theta in the direction which keeps away from the direction of a vertical bias field (rightward arrow head of drawing 3 A) to the normal H of the truck cross direction and a perpendicular direction. In addition, although the direction of the magnetization Mf of the free magnetic layer 4 has turned to the upper right side in the condition that the field by the detection current J was impressed, in the condition which shows in drawing 3 A, in the condition that the detection current J is not acting, the direction of the magnetization Hf of the free magnetic layer 4 is turned in the direction of vertical bias almost parallel to the truck cross direction. (However, although it was not necessarily the truck cross direction and parallel correctly since the joint field Hint committed between the 1st fixed magnetic layer 11, the anti-field (dipole field) based on the magnetic thickness of the 2nd fixed magnetic layer 12 and the 2nd fixed magnetic layer 12, and the free magnetic layer 4 existed, it illustrated as almost parallel as an example here.)
This is for the force in which the detection current field Hj which the detection current J will generate if the detection current J acts tends to act on magnetization of the free magnetic layer 4, and tends to make the magnetization direction of the free magnetic layer 4 incline to act. In the condition that this detection current field Hj acted and magnetization of the free magnetic layer 4 inclined, the sense of magnetization is set up so that the fixed magnetic layer 11, the direction of magnetization of 12, and the direction of the magnetization Mf of the free magnetic layer 4 may cross at right angles.
[0062] Although the direction of the magnetization of each class by it being in the magnetization condition of each class of a laminated structure shown in drawing 3 A is clear, since drawing 1 is drawing which looked at the laminated structure of drawing 3 A from the longitudinal direction (in X1 direction), the sense of the vector of the magnetization direction of the free magnetic layer 4 and the vector of the magnetization direction of the 2nd fixed magnetic layer 12 are indicated by the same direction, but it considers as the rectangular condition so that stereoscopic vision may be carried out to drawing 3 A in fact. Furthermore, since it is drawing which looked at the laminated structure of drawing 3 A in the direction of Y in drawing 2 , the sense of the vector of the magnetization direction of the free magnetic layer 4 and the sense of the vector of the magnetization direction of the 2nd fixed magnetic layer 12 are indicated 180 degrees in the opposite direction, but it considers as the rectangular condition so that stereoscopic vision may be carried out to drawing 3 A in fact.
[0063] Although drawing 3 B is the configuration of having assumed the case where a detection current flowed from left-hand side to the right-hand side sense, the direction of magnetization of each class is made into the case of the structure shown in drawing 3 A, and equivalence. Namely, the magnetization direction of said free magnetic layer 4 is arranged in the magnetization direction of said 2nd fixed magnetic layer 12, and the crossing direction, and the magnetization direction Mp3 of said 2nd fixed magnetic layer 12 inclines at the include angle theta in the direction which keeps away from the direction of a vertical bias field (facing the right of drawing 3) to the normal H of the truck cross direction and a perpendicular direction.
[0064] The range of two <= theta<=30 degrees is desirable, the range of theta has the more desirable range which is three <= theta<=15 degrees, and its range which is three <= theta<=10 degrees is [whenever / tilt-angle / to said normal H in the direction of the magnetization Mf (or Mf2) of said free magnetic layer 4] the most desirable. It is because the output as a magneto-resistive effect mold thin film will decline if having limited to the aforementioned range has [whenever / tilt-angle] too large theta exceeding 30 degrees, so an asymmetry improvement effect will become is hard to be acquired preferably if too small.
[0065] When the desired detection current field Hj is made to act according to the strength of the detection current field J, as for determining theta whenever [actual tilt-angle] in these range, it is most desirable to set up so that the magnetization direction of the free magnetic layer 4 may arrange in the magnetization direction of said 2nd fixed magnetic layer 12 and the direction which intersects perpendicularly. This is because the case where the magnetization direction of the free magnetic layer 4 rotates according to an operation of an external magnetic field is the most efficient and magnetic-reluctance change arises from the condition that the magnetization direction of the free magnetic layer 4 lies at right angles to the magnetization direction of said 2nd fixed magnetic layer 12 in the condition that the external magnetic field is not acting. Since the detection current J is set as a proper value by surrounding balance and a surrounding design manual with an electrical circuit here at the time of the design of the magnetic head, according to the magnitude of the detection current J, it will be decided in the above-mentioned include-angle range that it will be a suitable include angle.
[0066] Since the magnetization direction of the free magnetic layer 4 and the magnetization direction of the fixed magnetic layers 11 and 12 can be made to intersect perpendicularly in the condition of having passed the detection current J and having made the detection current field Hj acting in the magneto-resistive effect component GMR 1 of the 1st operation gestalt as explained above, asymmetry of a playback output can be lessened. Moreover, since it is a PtMn alloy, an above-mentioned XMn alloy, or an above-mentioned PtMnX' alloy, using it as an antiferromagnetism layer 1 can make a strong exchange anisotropy field able to act to the 1st fixed magnetic layer

11, and it can carry out pinning of the magnetization direction of the 1st fixed magnetic layer 11 strongly.
[0067] By the way, if it is in the structure of a synthetic ferry PINDO mold where the laminating of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 from which magnetic thickness differs like the structure of the 1st operation gestalt was carried out through the nonmagnetic interlayer 10, since the switched connection field which the antiferromagnetism layer 1 makes act to the synthetic magnetic moment of both the fixed magnetic layers 11 and 12 acts, pinning of the magnetization of the 1st fixed magnetic layer 11 can be carried out strongly.
[0068] Furthermore, pinning of the magnetization direction of the 2nd fixed magnetic layer 12 with the large magnetic moment is carried out by the switched connection field (RKKY interaction) by the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 confronting each other through the nonmagnetic interlayer 10. Moreover, since the sense of magnetization of the 1st fixed magnetic layer 11 and the sense of magnetization of the 2nd fixed magnetic layer 12 are in an anti-parallel condition different 180 degrees Although the great portion of magnetic moment of both the fixed magnetic layers 11 and 12 will balance, it will negate each other and some fields which remained will act on the external free magnetic layer 4 as an anti-field (dipole field) Hd from both the fixed magnetic layers 11 and 12 if the magnetic moment of both layers sees about the field which influences outside Although it had the problem which make asymmetry hard for the anti-field (dipole field) Hd to become small rather than the fixed magnetic layer of the conventional monolayer, and to double by the balance with the detection current field Hj with above-mentioned synthetic ferry PINDO structure Since the sense of magnetization of the fixed magnetic layers 11 and 12 and the free magnetic layer 4 can be made to intersect 90 degrees in the condition that the detection current field Hj acted, by adopting the above-mentioned magnetization structure, also in synthetic ferry PINDO structure, the problem of asymmetry is solvable.
[0069] That is, since the direction of magnetization of the free magnetic layer 4, and the fixed magnetic layer 11 and the direction of magnetization of 12 can be made to intersect 90 degrees correctly in the condition of having made the detection current field Hj acting, even if the sense of magnetization of the free magnetic layer 4 rotates under the effect of an external magnetic field, the exact resistance change corresponding to angle of rotation can be made to be able to discover, and the exact output which decreased asymmetry can be obtained.
[0070] Moreover, it is possible for it to be stabilized and to maintain magnetization of the 1st fixed magnetic layer 11 and magnetization of the 2nd fixed magnetic layer 12 at an anti-parallel condition, so that the switched connection field from the antiferromagnetism layer 1 is large. The alloy used especially with this operation gestalt can make a switched connection field strong as an antiferromagnetism layer 1 act, and since blocking temperature is also higher than the conventional alloy ingredients, such as FeMn, also thermally it is stabilized and it can maintain the magnetization condition of said 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12. With the structure of a **** 1 operation gestalt, the problem of asymmetry is also solvable on it.
[0071] The 1st example of the "manufacture approach of the 1st example", next the manufacture approach of a magneto-resistive effect mold thin film of having the structure of the 1st operation gestalt shown in drawing 1 - drawing 3 is explained. In this invention, in order to manufacture the magneto-resistive effect mold thin film of the structure shown in drawing 1 - drawing 3 , the laminating of the antiferromagnetism layer 1 which consists of antiferromagnetism ingredients, such as PtMn, on a substrate, the 1st fixed magnetic layer 11, the nonmagnetic interlayer 10, the 2nd fixed magnetic layer 12, the nonmagnetic conductive layer 3, the free magnetic layer 4 (it consists of the 1st free layer 13 and the 2nd free layer 14), and the protective layer 5 is carried out one by one. In the above laminated structure, the laminating condition of main layers is shown in drawing 7 A. In drawing 7 A, for simplification of explanation, only the antiferromagnetism layer 1, the 1st fixed magnetic layer 11, the 2nd fixed magnetic layer 12, and the free magnetic layer 4 are shown, and these layers are explained as a subject.
[0072] In addition, when forming the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12, it is good here also as membrane formation-among magnetic field processing in which a magnetic field is impressed in the direction which intersects perpendicularly to the truck cross direction. Moreover, when forming the free magnetic layer 4, it is desirable to impress the 1st field H1 in the 1st direction D1 (or the direction opposite to the 1st direction D1 180 degrees of D1A) which meets crosswise [truck], and to arrange the uniaxial anisotropy of the free magnetic layer 4 crosswise [truck].
[0073] If the layered product which carried out the laminating of these each class is obtained In the 2nd direction D2 in which only the predetermined include angle theta made the 1st heat treatment (heat treatment heated 60 minutes to about 480 minutes at 503K-553K;230 degree-C-280 degree C) for making the antiferromagnetism layers 1, such as PtMn, into ordered structure incline to the direction DA which intersects perpendicularly crosswise [truck] Impressing the 2nd strong field H2 of 400 or more kA/m, as shown in drawing 7 B, it carries out. In addition, although the conditions of magnetization of each class need to differ and it is necessary to impress a field H3 in the 3rd direction D3 of an opposite direction 180 degrees to the 2nd direction D2 depending on the case when the strength of the 2nd field H2 impressed in here is the weak field which is 8 kA/m - 80 kA/m extent, the direction of a magnetic field in the case of this weak magnetic field is explained in full detail behind.
[0074] Since regulation-ization of the antiferromagnetism ingredient which constitutes the antiferromagnetism

layer 1 is made and a strong switched connection field can be made to act on the 1st fixed magnetic layer 11 by 1st heat treatment performed by impressing the strong above-mentioned magnetic field of 400 or more kA/m While being able to turn the direction of magnetization of the 1st fixed magnetic layer 11 in the direction D2 of an impression field If an impression field is removed, magnetization of the 2nd fixed magnetic layer 12 is fixable to the 1st direction and 180-degree opposite direction of magnetization of the fixed magnetic layer 11 with the switched connection field (RKKY interaction) generated between the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12. Moreover, the direction of the easy axis of the uniaxial anisotropy of the free magnetic layer 4 will be in the condition that it was turned in the direction parallel to the 2nd above-mentioned direction D2 which made only the predetermined include angle theta incline to the direction DA which intersects perpendicularly crosswise [truck], or the direction of the easy axis of the original uniaxial anisotropy distributed, in the case of this 1st heat treatment.

[0075] Next Impressing the field H1 (H2> H1) weaker than the 2nd previous field H2 in the direction D1 (or the direction of D1A it turns [direction] to the opposite side 180 degrees) parallel to the truck cross direction, as shown in drawing 7 C The direction of the easy axis of the uniaxial anisotropy of the free magnetic layer 4 can be arranged in the direction D1 (or the direction of D1A it turns [direction] to the opposite side 180 degrees) parallel to the truck cross direction by performing annealing treatment in a magnetic field heated to 433K-513K (160 degrees C - 240 degrees C). In addition, what is necessary is just to perform annealing treatment in a magnetic field shown in drawing 7 C if needed, and even if it carries out the production process of the below-mentioned write head after omitting, it does not interfere.

[0076] Next, the process which forms an inductive head (induction type magnetic head for record) h2 as shown in drawing 5 is carried out after forming the vertical bias layer 7 and the current lead layer 8 as show the direction of magnetization to the both sides of the layered product arranged as shown in drawing 7 C at drawing 2 . The up gap layer 166 and the up shielding layer 167 are formed on a layered product, this up shielding layer 167 is used also [manufacture / of this inductive head h2] as a lower core layer 167 for inductive heads, the gap layer 174 is formed on it, and the induction coil 176 patternized so that it might become spiral superficially on it is formed by the photolithography method. Next, the insulating material layer 177 is formed so that this induction coil 176 may be covered. In case this insulating material layer 177 is formed, after applying a resin layer, in order to make it harden, heat treatment heated to the temperature of the range of 200 degree-C-280 degree-C;473K-553K is performed. The up core layer 178 is formed after heat treatment, and after processing this up core layer 178 and constituting magnetic gap WG for a store, an inductive head h2 is formed by forming a protective layer 179.

[0077] when it heats in heat treatment for previous resin hardening here more than 473K (200 degrees C), it is shown in drawing 7 E -- as -- a layered product -- even if it has formed the lower shielding layer 163 and the up shielding layer 167 up and down, directivity loses somewhat the easy axis of the uniaxial anisotropy of the free magnetic layer 4, the lower shielding layer 163, and the up shielding layer 167 -- having -- **** -- it becomes irregular and anisotropy distribution is produced. To therefore, a degree Impressing the 3rd field H3 weaker than the 2nd previous field H2 in the direction D1 (or the direction of D1A it turns [direction] to the opposite side 180 degrees) again parallel to the truck cross direction, as shown in drawing 7 F It is the direction D1 (or the opposite side 180 degrees) parallel to the truck cross direction about the direction of the easy axis of the uniaxial anisotropy of the free magnetic layer 4, the lower shielding layer 163, and the up shielding layer 167 by performing annealing treatment in a magnetic field heated to 433K-513K (160 degrees C - 240 degrees C). It can arrange in the direction of D1A to turn to. Since it is necessary to strengthen [which is extent to which magnetization of each class magnetized until now is not changed] it, the 3rd field H3 given here is enough if impressed by the strength of 8 or more kA/m and 40 or less kA/m extent.

[0078] Next, the 2nd previous field H2 is impressed to the vertical bias layers 7 and 7 prepared in the both sides of a previous layered product, the 4th field is impressed to the direction and hard flow which made the direction of magnetization of the 2nd fixed magnetic layer incline from the direction which intersects perpendicularly with the truck cross direction, and the vertical bias layer 7 is magnetized. In order to magnetize the vertical bias layer 7 here, the whole thing formed until now is installed in the interior of magnetic generators, such as an electromagnet, and it carries out by impressing in the direction which gave the uniaxial anisotropy of the free magnetic layer 4 for the field 400kA [/m] or more at a room temperature. By this processing, the vertical bias layer 7 can be magnetized, and the direction of magnetization of the free magnetic layer 4 can be arranged so that it may meet in the magnetization direction of the vertical bias layer 7 mostly. Since the magnetization processing of vertical bias performed here is a room temperature, it is uninfluential to the anisotropy of a free magnetic layer or a fixed magnetic layer. That is, although magnetic energy is large, since heat energy is small, it does not produce magnetic effect in these layers.

[0079] Since the detection current field Hj acts by passing a detection current to the current lead layer 8 to the magnetic-reluctance mold thin film manufactured as mentioned above and the sense of magnetization of the free magnetic layer 4 is changed from the continuous-line arrow head of drawing 7 G to a chain-line arrow head (arrow

head of the method sense of the diagonal below), the magnetization direction of the fixed magnetic layers 11 and 12 and the magnetization direction of the free magnetic layer 4 are made to intersect perpendicularly as a result. If the leakage field from a magnetic-recording medium acts to the magnetic-reluctance mold thin film of the above condition Since the sense of magnetization of the free magnetic layer 4 which lay at right angles to the magnetization direction of the fixed magnetic layers 11 and 12 rotates according to leakage magnetic field strength and the resistance change according to the angle of rotation arises The leakage field from a magnetic-recording medium is detectable by regarding the detection current change according to this resistance change as an output.

[0080] In "the strength of the field at the time of the 2nd heat treatment", next the manufacture approach of said 1st example, the thickness relation of each class in the case of performing 2nd heat treatment by the strong field of 400 or more kA/m and the thickness relation of each class in the case of performing 2nd heat treatment, impressing a field with weak 8 kA/m - 80 kA/m extent are explained. Moreover, when heat-treating impressing the strong previous field of 400 or more kA/m, and when heat-treating impressing a weak field, the following desirable relation exists in the thickness of the 1st fixed magnetic layer 11, and the thickness of the 2nd fixed magnetic layer 12.

[0081] If it is in the synthetic ferry PINDO structure where the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 were divided through the nonmagnetic middle class 10 like this invention structure It is desirable to rationalize the thickness ratio tp 2 of the thickness tp1 of said 1st fixed magnetic layer 12 and the 2nd fixed magnetic layer 14. As for (thickness tp1 of 1st fixed magnetic layer)/(thickness tp2 of the 2nd fixed magnetic layer), it is desirable that it is within the limits of 0.33 to 0.95, or 1.05-4. When the thickness of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 itself becomes thick at above-mentioned within the limits, since a switched connection field tends to fall, it is desirable [if it is this within the limits, a switched connection field can be enlarged, but] to rationalize the thickness of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 in this invention.

[0082] It is desirable that it is within the limits the thickness tp1 of the 1st fixed magnetic layer 12 and whose thickness tp2 of the 2nd fixed magnetic layer 12 are 10-70A for example, and the absolute value which lengthened the thickness tp2 of the 2nd fixed magnetic layer 14 from the thickness tp1 of the 1st fixed magnetic layer 12 is 2A or more in this invention.

[0083] If it is within the limits and a thickness ratio and thickness are adjusted [above-mentioned] proper, it is possible to acquire easily the synthetic switched connection field (Hex) of at least 40 or more kA/m by, for example, using the antiferromagnetism layer 1 which consists of a PtMn alloy. A synthetic switched connection field is the magnitude of the external magnetic field when becoming **R/R of the one half of maximum **R/R (resistance rate of change) here. Said synthetic switched connection field (Hex) It is a synthetic thing including all the fields, such as a switched connection field (RKKY interaction) generated between the switched connection field (exchange anisotropy field) and the 1st fixed magnetic layer 11 which are generated in the interface of the antiferromagnetism layer 1 and the 1st fixed magnetic layer 11, and the 2nd fixed magnetic layer 12.

[0084] Moreover, as for aforementioned (thickness tp1 of the 1st fixed magnetic layer 11)/(thickness tp2 of the 2nd fixed magnetic layer 12), in this invention, it is more desirable that it is within the limits of 0.53 to 0.95, or 1.05-1.8. Moreover, it is [above-mentioned] within the limits, and both the thickness tp1 of the 1st fixed magnetic layer 11 and the thickness tp2 of the 2nd fixed magnetic layer 12 are within the limits of 10-50A, and, as for the absolute value which moreover lengthened the thickness tp2 of the 2nd fixed magnetic layer 12 from the thickness tp1 of the 1st fixed magnetic layer 11, it is desirable [the thickness] that it is 2A or more. It is [above-mentioned] within the limits, and if the thickness tp1 of the thickness ratio of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 and the 1st fixed magnetic layer 11 and the thickness tp2 of the 2nd fixed magnetic layer 12 are adjusted proper, for example in the antiferromagnetism layer 1 of a PtMn alloy, the synthetic switched connection field of at least 40 or more kA/m can be acquired. Moreover, if it is the thickness ratio and thickness of above-mentioned within the limits, while a synthetic switched connection field (Hex) can be enlarged, **R/R (resistance rate of change) can also be made [the former and] high to the same extent.

[0085] It is possible for it to be stabilized and to maintain magnetization of the 1st fixed magnetic layer 11 and magnetization of the 2nd fixed magnetic layer 12 at an anti-parallel condition, so that a synthetic switched connection field is large. By using the PtMn alloy which blocking temperature is especially high as an antiferromagnetism layer 1 in this invention, and is moreover made to generate a large switched connection field (exchange anisotropy field) in an interface with the 1st fixed magnetic layer 11 Also thermally it is stabilized and the magnetization condition of said 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 can be maintained.

[0086] By the way, the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 are formed with the same quality of the material, and moreover, when especially the magnetic field under heat treatment is 8 - 80 kA/m as the thickness of said 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 is the same value, it is checked by experiment that a comprehensive switched connection field and **R/R fall extremely. When this is the value with

same magnetic thickness Ms-tp1 of the 1st fixed magnetic layer 11 and magnetic thickness Ms-tp2 of the 2nd fixed magnetic layer 12, When magnetization of said 1st fixed magnetic layer 11 and magnetization of the 2nd fixed magnetic layer 12 will not be in an anti-parallel condition but the direction variance (the amount of magnetic moments which is suitable in the various directions) of said magnetization increases, it is because whenever [with magnetization of the free magnetic layer 4 / angular relation] is uncontrollable proper.

[0087] In order to solve such a problem, when making [11] magnetic thickness Ms-tp1 of the 1st fixed magnetic layer 11 and magnetic thickness Ms-tp2 of the 2nd fixed magnetic layer 12 into a different value, i.e., the 1st fixed magnetic layer, and the 2nd fixed magnetic layer 12 are formed in the 1st with the same quality of the material, it is necessary to form said 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 by different thickness.

[0088] With this invention As mentioned above, the thickness ratio of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 is rationalized, but in the thickness ratio, when the thickness tp1 of said 1st fixed magnetic layer 11 and the thickness tp2 of the 2nd fixed magnetic layer 12 become the almost same value, specifically, the thickness ratio of 0.95-1.05 within the limits is excepted from the proper range.

[0089] Like this invention next, by giving a PtMn alloy etc. to the antiferromagnetism layer 1 and giving annealing in a magnetic field (heat treatment) after membrane formation When the antiferromagnetism ingredient made to generate a switched connection field (exchange anisotropy field) in an interface with the 1st fixed magnetic layer 11 is used Even if it sets magnetic thickness Ms-tp of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 as a different value Unless it controls the direction of the impression magnetic field under heat treatment, and its magnitude proper, direction variance cannot increase or it cannot control proper in the direction which wants to turn said magnetization to magnetization of the 1st fixed magnetic layer 11, and magnetization of the 2nd fixed magnetic layer 12.

[0090]

[Table 1]

第１の固定磁性層Ms・tP1＞第２の固定磁性層Ms・tP2

熱処理中の磁界方向	(1) ← 左に8kA/m ～80kA/m	(2) → 右に8kA/m ～80kA/m	(3) → 右に400kA/m 以上	(4) ← 左に400kA/m 以上
第１の固定磁性層の方向	←	→	→	←
第２の固定磁性層の方向	→	←	→	←
磁界除去後の磁化方向	← →	→ →	→ →	← ←
	→	←	←	→

[0091] In Table 1, when magnetic thickness Ms-tp1 of the 1st fixed magnetic layer 11 is larger than magnetic thickness Ms-tp2 of the 2nd fixed magnetic layer 12 and it changes the magnitude of the magnetic field under heat treatment, and its direction, magnetization of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 means which direction is turned to after in which direction it is suitable, and field removal during field impression.

[0092] In the case of (1) of Table 1, the 8 kA/m-80kA/m of the directions of the magnetic field under heat treatment is given to illustration left-hand side (<- direction). In this case, since magnetic thickness Ms-tp1 of the 1st fixed magnetic layer 11 is larger than magnetic thickness Ms-tp2 of the 2nd fixed magnetic layer 12 Magnetization of the 1st dominant fixed magnetic layer 11 tends to learn in the direction of an impression magnetic field, and magnetization of the 2nd fixed magnetic layer 12 tends to be in an anti-parallel condition (the direction of ->) toward the illustration left by the switched connection field (RKKY interaction) with the 1st fixed magnetic layer 11.

[0093] In the case of (2) of Table 1, if the magnetic field of 8 kA/m - 80 kA/m is impressed rightward (the direction of ->), magnetization of the 1st dominant fixed magnetic layer 11 will learn in the direction of an impression magnetic field, and magnetization of the 2nd fixed magnetic layer 12 will become anti-parallel (<- direction) to magnetization of the 1st fixed magnetic layer 11 toward the right.

[0094] In the case of (3) of Table 1, if the magnetic field of 400 or more kA/m is given rightward (the direction of ->), first, magnetization of the 1st dominant fixed magnetic layer 11 will be learned in the direction of an impression magnetic field, and will be suitable rightward. By the way, since the switched connection field (RKKY interaction) generated between the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 is 80 kA/m - 400 kA/m extent, if a magnetic field 400kA [/m] or more is impressed, the 2nd fixed magnetic layer 12 will also turn to the direction of an impression magnetic field, i.e., the illustration right, (-> direction). Similarly, in (4) of Table 1, if the magnetic field of 400 or more kA/m is impressed leftward (<- direction), both magnetization of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 will be suitable leftward [illustration] (<- direction).

[0095] However, in the case of (3) of Table 1, and (4), if the field which was being impressed is removed, by the switched connection field (RKKY interaction) generated between the 1st fixed magnetic layer 11 and the 2nd fixed

magnetic layer 12, the magnetization direction of the 2nd fixed magnetic layer 12 will be reversed, and the direction of magnetization of the 1st fixed magnetic layer 11 and the direction of magnetization of the 2nd fixed magnetic layer 12 will be [different 180 degrees] anti-parallel.

[0096]

[Table 2]

第１の固定磁性層Ms・tP1＜第２の固定磁性層Ms・tP2

熱処理中の磁界方向	(1) ← 左に8kA/m ～80kA/m	(2) → 右に8kA/m ～80kA/m	(3) → 右に400kA/m 以上	(4) ← 左に400kA/m 以上
第１の固定磁性層の方向	→	←	→	←
第２の固定磁性層の方向	←	→	→	←
磁界除去後の磁化方向	→	←	→	←
	←	→	←	→

[0097] In Table 2, when magnetic thickness Ms-tp1 of the 1st fixed magnetic layer 11 is smaller than magnetic thickness Ms-tp2 of the 2nd fixed magnetic layer 12 and it changes the magnitude of the impression magnetic field under heat treatment, and its direction, magnetization of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 means in which direction it is suitable [in which direction] during field impression, or suitable after field removal.

[0098] In the case of (1) of Table 2, if the magnetic field of 8 kA/m - 80 kA/m is given leftward [of a table], magnetization of the 2nd large fixed magnetic layer 12 of magnetic thickness Ms-tp2 becomes dominant, and magnetization of said 2nd fixed magnetic layer 12 will learn in the direction of an impression magnetic field, and will be suitable leftward [illustration]. By the switched connection between the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 (RKKY interaction), magnetization of said 1st fixed magnetic layer 12 becomes anti-parallel (the direction of ->) to magnetization of said 2nd fixed magnetic layer 12. Similarly, if the magnetic field of 8 kA/m - 80 kA/m is given rightward [illustration], magnetization of the 2nd dominant fixed magnetic layer 12 will be suitable [as for magnetization of the 1st fixed magnetic layer 11] in the case of (2) of Table 2, leftward [of a table] (<- direction) toward the right (-> direction) of a table.

[0099] In the case of (3) of Table 2, if the magnetic field of 400 or more kA/m is given rightward [of a table], both magnetization of said 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 will be suitable rightward [of a table] (the direction of ->) by impressing the magnetic field beyond the switched connection between the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 (RKKY interaction). In the case of (4) of Table 2 If the magnetic field of 400 or more kA/m is impressed leftward [of a table], both magnetization of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 will turn to the left (<- direction) of a table. However, in the case of (3) of Table 2, and (4), if the field which was being impressed is removed, by the switched connection field (RKKY interaction) generated between the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12, the magnetization direction of the 2nd fixed magnetic layer 12 will be reversed, and the direction of magnetization of the 1st fixed magnetic layer 11 and the direction of magnetization of the 2nd fixed magnetic layer 12 will be [different 180 degrees] anti-parallel.

[0100] When it is going to turn magnetization of the 1st fixed magnetic layer 11 rightward [of a table] (the direction of ->), here the direction of a magnetic field under proper heat treatment, and its magnitude In the structure where the magnetic thickness of the 1st fixed magnetic layer 11 is bigger than the magnetic thickness of the 2nd fixed magnetic layer 12 In the case of (2) in Table 1, and (3) (it sets in the column of the magnetization direction after field removal of Table 1, and is big referring to [of a vector] the rightward arrow head), the magnetic thickness of the 2nd fixed magnetic layer 12 sets in bigger structure than the magnetic thickness of the 1st fixed magnetic layer 11. It is the case (see the rightward small arrow head of a vector in the column of the magnetization direction after field removal of Table 2) of (1) in Table 2, and (3).

[0101] In both the cases of (2) of Table 1, and (3), magnetization of said 1st fixed magnetic layer 11 is fixed rightward toward the right by the switched connection field (exchange anisotropy field) in an interface with the antiferromagnetism layer 11 generated by heat treatment in response to the effect of the impression magnetic field of the right [magnetization / of the 1st large fixed magnetic layer 11 of magnetic thickness Ms-tp1] under heat treatment at this time. In the case of Table 1 (3), if the magnetic field of 400 or more kA/m is removed, the 2nd fixed magnetic layer 12 will reverse magnetization of said 2nd fixed magnetic layer 12 by the switched connection field (RKKY interaction) generated between the 1st fixed magnetic layer 11, and it will be suitable leftward (<- direction).

[0102] By the case of Table 2 (1) and (3), magnetization of the 1st fixed magnetic layer 11 turned rightward is similarly fixed rightward by the switched connection field (exchange anisotropy field) in an interface with the

antiferromagnetism layer 11. In the case of Table 2 (3), when the magnetic field of 400 or more kA/m is removed, the 2nd fixed magnetic layer 12 reverses magnetization of said 2nd fixed magnetic layer 12 by the switched connection field (RKKY interaction) generated between the 1st fixed magnetic layer 11, and it is fixed leftward (<- direction). On the other hand, when magnetic thickness of the 2nd fixed magnetic layer 12 is made larger than the magnetic thickness of the 1st fixed magnetic layer 11 and it impresses the field of the range of 8 kA/m - 80 kA/m Since it corresponds (1) of Table 2, and in the case of (2), the magnetization direction of the 1st fixed magnetic layer 11 serves as the direction of a field, and reverse sense during field impression, and after it stops field impression, it serves as the direction of a field, and magnetization of the reverse sense.

[0103] As it indicates Table 1 and Table 2 that it explained above by the size of the magnetic thickness of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12, and the size of an impression field, two or more combination arises. When the structure shown in previous drawing 1 - drawing 3 here is adopted, magnetic thickness of the 2nd fixed magnetic layer 12 is made larger than the magnetic thickness of the 1st fixed magnetic layer 11 and it impresses the 2nd field H2 of 400 or more kA/m, (3) of Table 2, and in the case of (4), it corresponds. Namely, although the sense of magnetization of the 1st fixed magnetic layer 11 and the sense of magnetization of the 2nd fixed magnetic layer 12 turn to D 2-way together when the 2nd field H2 of 400 or more kA/m which is suitable in the 2nd direction D2 in the approach explained previously is impressed Since D 2-way turns to the D3 direction of an opposite direction, the sense of magnetization of the 2nd fixed magnetic layer 12 by the switched connection field (RKKY interaction) which will be produced between the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 if this 2nd field H2 is removed It becomes the magnetization direction of each class as shown in drawing 7 B. Moreover, what is necessary is just to impress the 2nd direction D2 of previous in the D3 direction of an opposite direction 180 degrees, since it becomes being the same as that of the case of (1) of Table 2, and (2) when strengthening [of the range of 8 kA/m - 80 kA/m] magnetic field strength impressed in the previous approach.

[0104] Moreover, since the direction of magnetization and the relation of an impression field turn into relation shown in Table 1 temporarily when magnetic thickness of the 1st fixed magnetic layer 11 is made into larger structure than the magnetic thickness of the 2nd fixed magnetic layer 12 In this case, each can turn magnetization of the 1st fixed magnetic layer 11 in the 2nd direction D2 by impressing the field of 400 or more kA/m in the 2nd direction D2, or impressing the field of 8 kA/m - 80 kA/m.

[0105] By the way, as shown in Table 1 and 2, the magnitude of the magnetic field impressed during heat treatment is 8 kA/m - 80 kA/m or 400 kA/m or more, and has removed the magnitude of the magnetic field of the range of 80 kA/m - 400 kA/m from the proper range. This is based on the following reasons.

[0106] By giving a magnetic field, magnetization of a fixed magnetic layer with larger magnetic thickness Ms-tp is taken as the other side in the direction of a magnetic field. However, even magnetization of the small fixed magnetic layer of magnetic thickness Ms-t considers as the other side in the direction of a magnetic field for the magnitude of the magnetic field under heat treatment to be between 80 kA/m - 400 kA/m, strongly in response to the fact that the effect of a magnetic field. Magnetization of the two-layer fixed magnetic layer which is going to become anti-parallel does not become anti-parallel in response to the effect of a strong magnetic field, but the so-called magnetization variance which magnetization of said fixed magnetic layer makes the other side in the various directions increases, and it becomes impossible for this reason, to magnetize magnetization of a two-layer fixed magnetic layer in the anti-parallel condition proper by the switched connection field (RKKY interaction) generated between fixed magnetic layers. Therefore, in this invention, the magnitude of the magnetic field of 80 kA/m - 400 kA/m is removed from the proper range. In addition, it is because magnetization of the large fixed magnetic layer of magnetic thickness Ms-tp cannot be turned in the direction of an impression magnetic field unless having made magnitude of the magnetic field under heat treatment into 8 or more kA/m gives a magnetic field of this level.

[0107] In addition, if it is the case where the antiferromagnetism layer 11 which needs heat treatment is used, the magnitude of the magnetic field under heat treatment mentioned above and the control approach of the direction can be applied even when the object for facilities of the NiMn alloy which can carry out application possible, for example, is used as an antiferromagnetism layer 1 from the former is carried out, even if it is the case where what kind of antiferromagnetism ingredient is used.

[0108] By this invention approach, as mentioned above by storing the thickness ratio of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 within proper limits A comprehensive switched connection field (Hex) can be enlarged, magnetization of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 can be maintained at the anti-parallel condition (ferry condition) stabilized also thermally, and it is possible to secure **R/R (resistance rate of change) to the same extent as the former moreover. By furthermore controlling the magnitude of the magnetic field under heat treatment, and its direction proper, it becomes possible to control the magnetization direction of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 in the direction to acquire.

[0109] by the way -- as mentioned above, the magnetic moment (magnetic thickness) can be searched for by

addition of saturation magnetization Ms and Thickness t, for example, it is NiFe of a bulk solid-state -- saturation magnetization Ms -- about 1.0 -- it is T (tesla) and is Co of a bulk solid-state -- saturation magnetization Ms -- about 1.7 -- it is known that it is T. Therefore, when the thickness of said NiFe film is 30A, the magnetic thickness of said NiFe film is set to 30A and T. Since the magnetostatic energy of the ferromagnetic when adding a field from the exterior is proportional to crossing with magnetic thickness and an external magnetic field, when the large ferromagnetic of magnetic thickness and the small ferromagnetic of magnetic thickness are in the ferry condition by the RKKY interaction through the nonmagnetic interlayer, a ferromagnetic with larger magnetic thickness becomes easy to turn to the direction of an external magnetic field.

[0110] In however, the case of the ferromagnetic which carried out laminating contact with antiferromagnetism layers, such as a case of the ferromagnetic which carried out laminating contact with nonmagnetic membranes, such as a tantalum (Ta), and a ruthenium (Ru), copper (Cu), and PtMn film Since a nonmagnetic membrane atom, an antiferromagnetism film atom, and a ferromagnetic atom (nickel, Fe, Co) come into contact with directly, it is known that the saturation magnetization Ms of the ferromagnetic near an interface with a nonmagnetic membrane or the antiferromagnetism film will become smaller than the saturation magnetization (Ms) of a bulk solid-state. Furthermore, if heat treatment is performed to a ferromagnetic, a nonmagnetic membrane, and the laminating multilayers of an antiferromagnetism layer, it is known that interface diffusion will advance and distribution of the direction of thickness will arise in the saturation magnetization Ms of a ferromagnetic by said heat treatment. That is, saturation magnetization Ms is the phenomenon of approaching the saturation magnetization Ms of a bulk solid-state as the saturation magnetization Ms of the location near a nonmagnetic membrane or an antiferromagnetism layer is small and it separates from an interface with a nonmagnetic membrane or the antiferromagnetism film.

[0111] Reduction of the saturation magnetization Ms of a nonmagnetic membrane or the ferromagnetic of the location near an antiferromagnetism layer is in accuracy, in order to be dependent on the ingredient of a nonmagnetic membrane, the ingredient of an antiferromagnetism layer, the ingredient of a ferromagnetic, built-up sequence, heat treatment temperature, etc. It must ask in each specified condition. The magnetic thickness in this invention is the value which also took into consideration and computed the decrement of the saturation magnetization Ms produced by thermal diffusion with a nonmagnetic membrane or an antiferromagnetism layer.

[0112] Although it is required to form a diffusion layer by the interface of the PtMn film and a ferromagnetic by heat treatment in order to acquire a switched connection field by the interface of the antiferromagnetism layer of PtMn, and a ferromagnetic, reduction of the saturation magnetization Ms of the ferromagnetic accompanying formation of a diffusion layer will be dependent on the built-up sequence of the PtMn film and a ferromagnetic.

[0113] If it is like the structure shown especially in drawing 1 in the case of the magneto-resistive effect thin film of the so-called bottom type with which the antiferromagnetism layer 1 is formed below the free magnetic layer 4 of spin bulb mold, it is easy to generate a thermal diffusion layer in the interface of said antiferromagnetism layer 1 and the 1st fixed magnetic layer 11, and, for this reason, the magnetic thickness of said 1st fixed magnetic layer 11 is small compared with the actual thickness tp1. However, when the magnetic thickness of said 1st fixed magnetic layer 11 becomes small too much, a magnetic thickness difference with the 2nd fixed magnetic layer 12 becomes large too much, and when the rate of the thermal diffusion layer occupied to said 1st fixed magnetic layer 11 increases, there is a problem of leading to the fall of a switched connection field.

[0114] Namely, the antiferromagnetism layer 1 which needs heat treatment like this invention since a switched connection field is generated in an interface with the 1st fixed magnetic layer 11 is used. In order to change the magnetization condition of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 into a ferry condition Unless it rationalizes not only rationalization of the thickness of said 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 but said magnetic thickness of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12, the stable magnetization condition cannot be maintained.

[0115] If there is no difference in the magnetic thickness of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 to some extent as mentioned above, a magnetization condition leads to the fall of a switched connection field and is not desirable, even if it will be hard to be in a ferry condition and the difference of the magnetic thickness of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 becomes large too much. So, as for (magnetic thickness of 1st fixed magnetic layer 11)/(magnetic thickness of the 2nd fixed magnetic layer 12), in this invention, it is desirable like the thickness ratio of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 that it is within the limits of 0.33 to 0.95, or 1.05-4. Furthermore, it is desirable that it is within the limits the magnetic thickness of the 1st fixed magnetic layer 11 and whose magnetic thickness of the 2nd fixed magnetic layer 12 are 10-70 (AandT) in this invention, and the absolute value which lengthened the magnetic thickness of the 2nd fixed magnetic layer 12 from the magnetic thickness of the 1st fixed magnetic layer 11 is more than two (AandT).

[0116] Moreover, (magnetic thickness of 1st fixed magnetic layer 11)/(magnetic thickness of the 2nd fixed magnetic layer 12) is 0.53-0.95 similarly. Or it is more desirable that it is within the limits of 1.05-1.8. Moreover, it is [above-mentioned] within the limits, and both the magnetic thickness of the 1st fixed magnetic layer 11 and the

magnetic thickness of the 2nd fixed magnetic layer 12 are within the limits of 10-50 (AandT), and, as for the absolute value which moreover lengthened the magnetic thickness of the 2nd fixed magnetic layer 12 from the magnetic thickness of the 1st fixed magnetic layer 11, it is desirable that it is more than two (AandT).
[0117] The 2nd example of the "manufacture approach of the 2nd example", next the manufacture approach of a spin bulb mold magneto-resistive effect component of having the structure of the 1st operation gestalt shown in drawing 1 - drawing 3 is explained below based on drawing 8 . In the manufacture approach of the 2nd example, in order to manufacture the magneto-resistive effect mold thin film of the structure shown in drawing 1 - drawing 3 , the laminating of the antiferromagnetism layer 1 which consists of PtMn on a substrate, the 1st fixed magnetic layer 11, the nonmagnetic interlayer 10, the 2nd fixed magnetic layer 12, the nonmagnetic conductive layer 3, the free magnetic layer 4 (it consists of the 1st free layer 13 and the 2nd free layer 14), and the protective layer 5 is carried out one by one. In the above laminated structure, the laminating condition of main layers is shown in drawing 8 A. In drawing 8 A, only the antiferromagnetism layer 1, the 1st fixed magnetic layer 11, the 2nd fixed magnetic layer 12, and the free magnetic layer 4 are shown for simplification of explanation, and it explains below by making these into a subject.
[0118] In addition, when forming the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12, a magnetic field may be impressed in the direction which intersects perpendicularly to the truck cross direction here. Moreover, when forming the free magnetic layer 4, it is desirable to impress the 1st field H1 in the 1st direction D1 (or the direction opposite to D1 direction 180 degrees of D1A) which meets crosswise [truck], and to arrange the uniaxial anisotropy of the free magnetic layer 4 crosswise [truck].
[0119] If the layered product which carried out the laminating of these each class is obtained, as shown in drawing 8 B, it will carry out impressing the 2nd strong field H12 of 400 or more kA/m in the 2nd direction DA which intersects perpendicularly crosswise [truck] the 2nd heat treatment for making the antiferromagnetism layer 1 of PtMn into ordered structure which carries out heat treatment (it is 60 minutes - 480 minutes to 503K-553K;230 degree-C-280 degree C) extent heating. In addition, it is the weak magnetic field whose strength of the 2nd field H12 to impress is 8 kA/m - 80 kA/m extent, and when the magnetic thickness of the 2nd fixed magnetic layer is thicker than the magnetic thickness of the 1st fixed magnetic layer, the conditions of magnetization of each class need to differ and it is necessary to impress the 2nd field H12 in the 3rd direction DB of an opposite direction 180 degrees to the 2nd direction DA here. The direction of the magnetization in the case of impressing this 2nd field and magnetizing the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 What is necessary is just to determine the field impression direction like the case where considered the size relation between the magnetic thickness of the 1st fixed magnetic layer 11, and the magnetic thickness of the 2nd fixed magnetic layer 12, and the size relation of an impression field, and it explains previously based on Table 1 and Table 2, since it is equivalent to the case where it explains based on drawing 7 , Table 1, and Table 2 previously.
[0120] For example, like [in the case of being shown in Table 1], when the magnetic thickness of the 1st fixed magnetic layer 11 is large, even if it is the impression field of the range of 8kA/m - 80 kA/m and is the case of the impression field of 400 or more kA/m, the sense of magnetization of the 1st fixed magnetic layer 11 can be arranged in the direction of an impression field, and the sense of magnetization of the 2nd fixed magnetic layer 12 can be arranged with the direction and opposite direction of an impression field. As shown in Table 2, moreover, when the magnetic thickness of the 2nd fixed magnetic layer 12 is large In the impression field of the range of 8 kA/m - 80 kA/m, the sense of magnetization of the 1st fixed magnetic layer is arranged with the direction and hard flow of an impression field. The sense of magnetization of the 2nd fixed magnetic layer can be arranged in the direction of an impression field, when it is the impression field of 400 or more kA/m, the direction of magnetization of the 1st fixed magnetic layer 11 can be arranged in the direction of an impression field, and the sense of magnetization of the 2nd fixed magnetic layer 12 can be arranged with an impression field and an opposite direction.
[0121] Since regulation-ization of the antiferromagnetism layer 1 is made and a strong switched connection field is made to act on the 1st fixed magnetic layer 11 by 1st heat treatment performed by impressing the 2nd strong above-mentioned field H12 of 400 or more kA/m While turning to the direction of magnetization of the 1st fixed magnetic layer 11 in the direction DA of the 2nd field H12 Magnetization of the 2nd fixed magnetic layer 12 is fixable in the direction of magnetization of the 1st fixed magnetic layer 11, and the 3rd direction DB of a 180-degree opposite direction with the switched connection field (RKKY interaction) generated between the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12. Moreover, the direction of the easy axis of the uniaxial anisotropy of the free magnetic layer 4 will be in the condition that it was turned in the direction parallel to the directions DA and DB which intersect perpendicularly crosswise [truck], or the direction of the easy axis of the original uniaxial anisotropy distributed, when a field H12 is impressed in the 2nd direction DA.
[0122] As shown in drawing 8 C, next, in the direction D1 (or direction D1A which turns to the opposite side 180 degrees) parallel to the truck cross direction Impressing the annealing field H22 weaker than the 2nd previous field H12 The direction of the easy axis of the uniaxial anisotropy of the free magnetic layer 4 is arranged in the

direction D1 (or the direction of D1A it turns [direction] to the opposite side 180 degrees) parallel to the truck cross direction by performing annealing treatment in a magnetic field heated to 433K-513K (160 degrees C - 240 degrees C). In addition, what is necessary is just to perform annealing treatment in a magnetic field performed at this process if needed, and even if it carries out the production process of the below-mentioned write head after omitting, it does not interfere.

[0123] Next, after forming the vertical bias layer 7 and the current lead layer 8 as show the direction of magnetization to the both sides of the layered product arranged as shown in drawing 8 C at drawing 2 , the write head formation process for forming an inductive head h2, as shown in drawing 5 is carried out, as shown in drawing 8 D. The up gap layer 166 and the up shielding layer 167 are formed on a layered product, this up shielding layer 167 is used also [manufacture / of this inductive head h2] as a lower core layer 167 for inductive heads, the gap layer 174 is formed on it, and the induction coil 176 patternized so that it might become spiral superficially on it is formed by the photolithography method. Next, the insulating material layer 177 is formed so that this induction coil 176 may be covered. In case this insulating material layer 177 is formed, after applying a resin layer, in order to make it harden, heat treatment heated to the temperature of the range of 473K-553K (200 degrees C - 280 degrees C) is performed. The up core layer 178 is formed after heat treatment, and the aftercare layer 179 which processed this up core layer 178 and constituted magnetic gap WG for a store is formed.

[0124] when it heats in heat treatment for previous resin hardening here more than 473K (200 degrees C), it is shown in drawing 8 E -- as -- a layered product -- even if it has formed the up shielding layer 167 and the lower shielding layer 163 up and down, as for the easy axis of the uniaxial anisotropy of the free magnetic layer 4, the lower shielding layer 163, and the up shielding layer 167, directivity produces turbulence and the so-called anisotropy distribution. By therefore, the thing for which annealing treatment in a magnetic field heated to 3rd heat-treatment-temperature T3 of the range of 433K-513K (160 degrees C - 240 degrees C) is performed next, impressing the 3rd field H13 of 400 or less kA/m to direction D1A again parallel to the truck cross direction as shown in drawing 8 F While being able to turn in the 4th direction D14 in which only the include angle theta made the sense of magnetization of the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 incline to the 2nd direction DA which intersects perpendicularly crosswise [truck] The direction of the easy axis of the uniaxial anisotropy of the free magnetic layer 4, the lower shielding layer 163, and the up shielding layer 167 can be arranged with direction D1A parallel to the truck cross direction. Since laminating ferry PINDO structure will be broken down whenever [tilt-angle] here if this field is not much large although control of theta is controllable by the magnitude of the 3rd field H13, it is desirable to impress a field smaller than the switched connection field of laminating ferry PINDO structure. Moreover, while adjusting the magnitude of the 3rd field H13, it is possible also by adjusting the 3rd heat treatment temperature T13 to adjust the magnitude of theta whenever [tilt-angle].

[0125] Next, the 4th field H14 is impressed in the 5th direction D15 contrary to the direction which the 3rd previous field H13 was impressed [direction] to the vertical bias layers 7 and 7 prepared in the both sides of a previous layered product, and made magnetization of the 2nd fixed magnetic layer 12 incline, and the vertical bias layer 7 is magnetized. In order to magnetize the vertical bias layer 7 here, the whole thing formed until now is installed in the interior of magnetic generators, such as an electromagnet, and it carries out by impressing in the direction which gave the uniaxial anisotropy of the free magnetic layer 4 for the magnetic field more than 400 kA/m extent at a room temperature. By this processing, the vertical bias layer 7 can be magnetized, and the direction of magnetization of the free magnetic layer 4 can be arranged so that it may meet in the magnetization direction of the vertical bias layer 7 mostly.

[0126] Since the detection current field Hj acts by passing a detection current to the current lead layer 8 to the magnetic-reluctance mold thin film manufactured as mentioned above and the sense of magnetization of the free magnetic layer 4 is changed in the direction of slant, as shown in drawing 8 G, the magnetization direction of the free magnetic layer 4 serves as diagonal below sense, and the magnetization direction of the fixed magnetic layers 11 and 12 and the magnetization direction of the free magnetic layer 4 will intersect perpendicularly as a result.

[0127] If the leakage field from a magnetic-recording medium acts to the magnetic-reluctance mold thin film of the above condition Since the sense of magnetization of the free magnetic layer 4 which lay at right angles to the magnetization direction of the fixed magnetic layers 11 and 12 rotates according to leakage magnetic field strength and the resistance change according to the angle of rotation arises The leakage field from a magnetic-recording medium is detectable by regarding the detection current change according to this resistance change as an output.

[0128] In addition, although the manufacture approach of said 2nd example described the manufacture approach of structure when the magnetic thickness of the 2nd fixed magnetic layer 12 is larger than the magnetic thickness of the 1st fixed magnetic layer 11 When manufacturing structure when the magnetic thickness of the 1st fixed magnetic layer 11 is larger than the magnetic thickness of the 2nd fixed magnetic layer 12, the 3rd field H13 explains the impression direction in beyond abbreviation 240 A/m-400 kA/m below further. The relation between the magnetic thickness of the fixed magnetic layers 11 and 12, impression magnetic field strength, and a direction turns into relation similar to the case where it explains using Table 1 and Table 2 in explanation of the manufacture

approach of the 1st previous example. In this case, that exchange anisotropy with the antiferromagnetism layer 1 has already acted on the 1st fixed magnetic layer 11 will differ from the case of Table 1 and Table 2, and it will incline in that direction, without the ability turning magnetization in the direction of that arrow head completely, even if it impresses the same field as Table 1 and Table 2. Moreover, in this case, since [of a cascade screen] the shielding layers 163 and 167 exist up and down, a part of impressed field is inhaled by the shielding layers 163 and 167, and the effective magnetic field which acts on the fixed magnetic layer 11 or the free magnetic layer 4 becomes below abbreviation one half of an impression field.

[0129] Therefore, in the manufacture approach of said 2nd example, when impressing said 3rd field H13 and considering as the weak field of abbreviation 8K - 80 kA/m or more than it, abbreviation 120 kA/m - 400 kA/mor less **, the 3rd field H13 is turned in the 3rd direction D1 of an opposite direction 180 degrees with D1A parallel to the truck cross direction, and is impressed. Moreover, also when impressing the 3rd field H13 and impressing the field beyond abbreviation 120 kA/m-400 kA/m, it shall turn in the direction D1 parallel to the truck cross direction. However, since controlling correctly is not easy so that only an include angle theta may make the direction of magnetization incline if the field of 400 or more kA/m is impressed when impressing the 3rd field H13, as an impression field, the weak field of 8K - 80 kA/m or more than it, abbreviation 240 kA/m - 400 kA/m is more desirable.

[0130] It is the sectional view showing typically the structure at the time of seeing the spin bulb mold magneto-resistive effect component which shows "2nd operation gestalt" drawing 9 in the typical structure section Fig. of the spin bulb mold magneto-resistive effect component of the 2nd operation gestalt of this invention, and shows drawing 10 to drawing 9 from an opposed face with a magnetic-recording medium. It is prepared in the trailing side edge section of the surfacing type slider formed in the hard disk drive unit etc. like the spin bulb mold magneto-resistive effect component shown in drawing 1 - drawing 3 also in the spin bulb mold magneto-resistive effect component GMR 2 of this operation gestalt, and the record field of magnetic-recording media, such as a hard disk, is detected. The spin bulb mold magneto-resistive effect component GMR 2 of this 2nd operation gestalt divides not only the fixed magnetic layers 11 and 12 but a free magnetic layer through a nonmagnetic interlayer to two-layer [of the 1st free magnetic layer and the 2nd free magnetic layer].

[0131] In the structure shown in drawing 9 and drawing 10 , the same sign is given to the same thing as the structure of the 1st operation gestalt shown in drawing 1 - drawing 3 , and detailed explanation of those parts is omitted. Although it is equivalent to the previous 1st operation gestalt in the structure of this 2nd operation gestalt about the structure where the laminating of the 1st fixed magnetic layer 11, the nonmagnetic interlayer 10, the 2nd fixed magnetic layer 12, and the nonmagnetic conductive layer 3 is carried out on the antiferromagnetism layer 1 On the nonmagnetic conductive layer 3, a laminating is carried out to the order of the 1st free magnetic layer 20, the nonmagnetic interlayer 21, the 2nd free magnetic layer 22, and a protective layer 5, and the layered product S2 is constituted. The ingredient which constitutes said each class is equivalent to the thing of a previous operation gestalt, and good.

[0132] That is, the 1st fixed magnetic layer 11 and the 2nd fixed magnetic layer 12 are formed with Co film, the NiFe alloy, the CoFe alloy, or the CoNiFe alloy. Moreover, as for the nonmagnetic interlayer 10, it is desirable to be formed with one sort or two sorts or more of alloys among Ru, Rh, Ir, Cr, Re, and Cu. The nonmagnetic conductive layer 3 is formed by Cu, Cr, etc.

[0133] Moreover, as for the nonmagnetic interlayer 21 who intervenes with this operation gestalt between the 1st free magnetic layer 20 and the 2nd free magnetic layer 22, it is desirable to be formed with one sort or two sorts or more of alloys among Ru, Rh, Ir, Cr, Re, and Cu. Magnetization of said 1st fixed magnetic layer 11 and magnetization of the 2nd fixed magnetic layer 12 are in the ferry condition mutually magnetized by anti-parallel, for example, magnetization of the 1st fixed magnetic layer 11 is being fixed to the previous structure and the previous EQC of the 1st operation gestalt in the direction where magnetization of the 2nd fixed magnetic layer 12 is equivalent to the structure of the previous 1st operation gestalt.

[0134] The 1st free magnetic layer 20 is formed on the nonmagnetic conductive layer 3 shown in drawing 9 and drawing 10 . As shown in drawing 9 and drawing 10 , said 1st free magnetic layer 20 is formed by two-layer, and the 1st free layer 27 which becomes the side which touches the nonmagnetic conductive layer 3 from Co is formed. The 1st free layer 27 which becomes the side which touches the nonmagnetic conductive layer 3 from Co is formed for preventing element diffusion with the nonmagnetic conductive layer 3 with the ability of **R/R being enlarged to the 1st the 2nd. On said 1st free layer 27, the 1st free layer 28 which consists of a NiFe alloy etc. is formed. Furthermore, the nonmagnetic interlayer 21 is formed on the 2nd free layer 28. And the 2nd free magnetic layer 22 is formed on said nonmagnetic interlayer 21, and the protective layer 5 is further formed on said 2nd free magnetic layer 22. Said 2nd free magnetic layer 22 is formed with Co film, the NiFe alloy, the CoFe alloy, or the CoNiFe alloy.

[0135] The side face is deleted in an inclined plane, and said layered product S2 is formed for the layered product S2 from the antiferromagnetism layer 1 shown in drawing 9 and drawing 10 to a protective layer 5 in the shape of a

cross-section isosceles trapezoid. The laminating of the vertical bias layer 7 and the current lead layer 8 is carried out to the both sides of said layered product S2 like the structure of a previous operation gestalt. When said vertical bias layer 7 is magnetized by illustration X1 direction and the 180-degree opposite direction, a vertical bias field is impressed to the free magnetic layer 20, and magnetization of the free magnetic layer 20 is arranged with illustration X1 direction and the 180 outlines opposite direction in the condition that the detection current field is not impressed.

[0136] The nonmagnetic interlayer 21 intervenes between the 1st free magnetic layer 20 shown in drawing 9 and drawing 10 , and the 2nd free magnetic layer 22, and the switched connection field (RKKY interaction) generated between said 1st free magnetic layer 20 and the 2nd free magnetic layer 22 changes mutually magnetization of said 1st free magnetic layer 20, and magnetization of the 2nd free magnetic layer 22 into the anti-parallel condition (ferry condition).

[0137] In the spin bulb mold thin film magnetic cell shown in drawing 9 and drawing 10 , the thickness tF1 of the 1st free magnetic layer 20 is formed smaller than the thickness tF2 of the 2nd free magnetic layer 22, for example. And the magnetic thickness (Ms-tF1) of said 1st free magnetic layer 20 In the condition that it is set up smaller than the magnetic thickness (Ms-tF2) of the 2nd free magnetic layer 22, and the detection current field is not acting If a bias field is given to illustration X1 direction and a 180 outlines opposite direction from the vertical bias layer 7 While magnetization of the 2nd free magnetic layer 22 with large magnetic thickness (Ms-tF2) is arranged with illustration X1 direction and 180 degree opposite direction of outlines in response to the effect of said bias field By the switched connection field (RKKY interaction) with said 2nd free magnetic layer 22, magnetization of the 1st free magnetic layer 20 with small magnetic thickness (Ms-tF1) is arranged in the direction near illustration X1.

[0138] However, also in a **** 2 operation gestalt, when the detection current field Hj acts, the free magnetic layer 20, the direction of magnetization of 22, and the fixed magnetic layer 11 and the direction of magnetization of 12 serve as an angular relation-ship equivalent to the case where it is shown in drawing 3 R> 3. However, since a free magnetic layer consists of two-layer structure of the 1st free magnetic layer 20 and the 2nd free magnetic layer 22 with a **** 2 operation gestalt It becomes in the same direction as the direction of the magnetization Mf of the free magnetic layer 4 in the case of the 1st operation gestalt which the direction of magnetization of the 2nd free magnetic layer 22 with big magnetic thickness shows to drawing 3 . The direction of magnetization of the 1st free magnetic layer 20 with small magnetic thickness turns into the direction and 180-degree opposite direction of the magnetization Mf of the free magnetic layer 4 of the 1st operation gestalt shown in drawing 3 . [of a case]

[0139] If the external magnetic field of a magnetic-recording medium invades [of drawing 9 and drawing 10] from Y, magnetization of said 1st free magnetic layer 20 and the 2nd free magnetic layer 22 will rotate in response to the effect of said external magnetic field, maintaining a ferry condition. And with the relation between fluctuation magnetization of the 1st free magnetic layer 20 which **** to **R/R, and fixed magnetization of the 2nd fixed magnetic layer 12, electric resistance changes and an external magnetic field is detected as electric resistance change. Since the vertical bias field is impressed to the free magnetic layers 20 and 22 by magnetization of the vertical bias layer 7 in that case, a smooth resistance change which does not produce a Barkhausen noise can be obtained. In the structure of a **** 2 operation gestalt, about other effectiveness, it is equivalent to the spin bulb mold magneto-resistive effect component of the previous 1st operation gestalt, when the detection current field Hj acts, it is constituted so that both the sense of magnetization of the 1st free magnetic layer 20 and the sense of magnetization of the fixed magnetic layer 2 and the sense of magnetization of the 2nd free magnetic layer 22 may cross at right angles, and thereby, asymmetry can be decreased.

[0140] "3rd operation gestalt" drawing 11 and drawing 12 are the cross-sectional views having shown the structure of the spin bulb mold thin film magnetic cell of the 3rd operation gestalt of this invention in mimetic diagram. The magneto-resistive effect mold thin film magnetic cell GMR 3 of this gestalt is a top type spin bulb mold magneto-resistive effect component which made reverse the film configuration of the bottom type spin bulb mold magneto-resistive effect component equipped with the antiferromagnetism layer, and formed it in the pars-basilaris-ossis-occipitalis side near a substrate as shown in drawing 1 - drawing 3 .

[0141] That is, if it is in the spin bulb mold thin film magnetic cell GMR 3 shown in drawing 11 and drawing 12 , a laminating is carried out in the order of the substrate film 30, the NiFe film 32, the Co film 33 (the NiFe film 32 and the Co film 33 are set, and it is the free magnetic layer 31), the nonmagnetic conductive layer 34, the 2nd fixed magnetic layer 35, the nonmagnetic interlayer 36, the 1st fixed magnetic layer 37, the antiferromagnetism layer 38, and a protective layer 39, and the layered product S3 is constituted. As for said antiferromagnetism layer 38, it is desirable to be formed with a PtMn alloy or a XMn alloy equivalent to the antiferromagnetism layer 1 of the previous 1st operation gestalt, and the XMnX' alloy.

[0142] Next, as for the nonmagnetic interlayer 36 who intervenes between the 1st fixed magnetic layer 37 and the 2nd fixed magnetic layer 35 which are shown in drawing 11 and drawing 12 , it is desirable to be formed with one sort or two sorts or more of alloys among Ru, Rh, Ir, Cr, Re, and Cu. With the spin bulb mold magneto-resistive effect component GMR 3 shown in drawing 11 and drawing 12 , the thickness tP1 of the 1st fixed magnetic layer

37 is formed with a different value from the thickness tP2 of the 2nd fixed magnetic layer 35, for example, the direction of the thickness tP1 of said 1st fixed magnetic layer 37 is formed more thickly than the thickness tP2 of the 2nd fixed magnetic layer 35, for example. Magnetization of said 1st fixed magnetic layer 37 and magnetization of the 2nd fixed magnetic layer 35 are in the ferry condition mutually magnetized by anti-parallel, for example, magnetization of the 1st fixed magnetic layer 37 and the 2nd fixed magnetic layer 35 is being fixed in the direction which has the X1 direction component shown in the direction component of Y and drawing 12 which are shown in drawing 11 . In addition, as shown in drawing 12 , the vertical bias layer 7 and the current lead layer 8 are formed in the right-and-left both sides of the layered product S3 from the substrate film 30 to a protective layer 39 like the structure of the previous 1st operation gestalt, and magnetization of the free magnetic layer 31 is arranged with illustration X1 direction and the 180-degree opposite direction by impressing a vertical bias field from said vertical bias layer 7.

[0143] However, also in a **** 3 operation gestalt, when the detection current field Hj acts, the direction of magnetization of the free magnetic layer 31, and the fixed magnetic layer 35 and the direction of magnetization of 37 serve as the same angular relation-ship as what is guessed from the case where it is shown in drawing 3 .

[0144] With the spin bulb mold magneto-resistive effect component GMR 3 in drawing 11 and drawing 12 , a detection current is given to the free magnetic layer 31, the nonmagnetic conductive layer 34, and the fixed magnetic layers 35 and 37 from said current lead layer 8. If a field is given in the direction of illustration Y shown in drawing 12 R> 2 from a record medium, when magnetization of the free magnetic layer 31 is changed in the direction of Y from illustration X1 direction and a 180-degree opposite direction and dispersion of the conduction electron for which it depended on spin by the interface of the nonmagnetic conductive layer 34 at this time and the free magnetic layer 31 and the interface of the nonmagnetic conductive layer 34 and the 2nd fixed magnetic layer 35 takes place, electric resistance will change and the leak field from a record medium will be detected. A vertical bias field is impressed to the free magnetic layer 31 by magnetization of the vertical bias layer 7 in that case. Like the case where it is guessed from [which is shown in drawing 3 as a result on which the detection current field Hj acts according to a detection current] magnetization The direction of magnetization of the free magnetic layer 31, and the fixed magnetic layer 35 and the direction of magnetization of 37 will be in the condition of having intersected 90 degrees. Since the leakage field from a record medium acts on the spin bulb mold magneto-resistive effect component GMR 3 of this condition and the sense of magnetization of the free magnetic layer 31 rotates While being able to obtain a big resistance change, since-izing of the free magnetic layer 31 can be carried out [single domain] by vertical bias, a smooth resistance change which does not produce a Barkhausen noise can be obtained. In the structure of a **** 3 operation gestalt, about other effectiveness, it is equivalent to the spin bulb mold magneto-resistive effect component of the previous 1st operation gestalt, namely, when the detection current field Hj acts, it is constituted so that the sense of magnetization of the 1st fixed magnetic layer 37 or the 2nd fixed magnetic layer 35 and the sense of magnetization of the free magnetic layer 31 may cross at right angles, and thereby, asymmetry can be decreased.

[0145] The cross-sectional view in which "4th operation gestalt" drawing 13 showed the spin bulb mold magneto-resistive effect component of the 4th operation gestalt of this invention in mimetic diagram, and drawing 14 are the sectional views showing typically the cross-section structure at the time of seeing the spin bulb mold magneto-resistive effect component shown in drawing 13 from an opposed face with a record medium. The spin bulb mold magneto-resistive effect component GMR 4 of this 4th operation gestalt makes reverse sequence of the laminating of the spin bulb mold thin film magnetic cell indicated to be drawing 9 R> 9 to 10. That is, it considers as the spin bulb mold magneto-resistive effect component of the top type by which the laminating was carried out in the order of the substrate film 40, the 2nd free magnetic layer 41, the nonmagnetic interlayer 42, the 1st free magnetic layer 43, the nonmagnetic conductive layer 46, the 2nd fixed magnetic layer 47, the nonmagnetic interlayer 48, the 1st fixed magnetic layer 49, the antiferromagnetism layer 50, and a protective layer 51 from the bottom. Said substrate film 40 and protective layer 51 are formed by Ta etc. As for said antiferromagnetism layer 50, it is desirable to be formed with the PtMn alloy, the XMn alloy, or the XPtX' alloy.

[0146] The 1st fixed magnetic layer 49 and the 2nd fixed magnetic layer 47 are formed with Co film, the NiFe alloy, the CoFe alloy, or the CoNiFe alloy. Moreover, as for the nonmagnetic interlayer 48, it is desirable to be formed with one sort or two sorts or more of alloys among Ru, Rh, Ir, Cr, Re, and Cu. Furthermore, the nonmagnetic conductive layer 46 is formed by Cu etc.

[0147] With the spin pulp mold magneto-resistive effect component GMR 4 shown in drawing 14 , the free magnetic layer is divided and formed in two-layer, the 1st free magnetic layer 43 is formed in the side which touches the nonmagnetic conductive layer 46, and another free magnetic layer is the 2nd free magnetic layer 41. As shown in drawing 14 , said 1st free magnetic layer 43 is formed by two-layer, and the 1st free layer 45 formed in the side which touches the nonmagnetic conductive layer 46 is formed by Co film. Moreover, the 1st free layer 44 formed in the side which touches the nonmagnetic interlayer 42, and the 2nd free magnetic layer 41 are formed with for example, the NiFe alloy, the CoFe alloy, or the CoNiFe alloy, and layered product S4 is constituted by

these laminatings.
[0148] As for layered product S4 of the configuration from the substrate film 40 shown in drawing 14 to a protective layer 51, the side face is deleted in an inclined plane, and said layered product S4 is formed with cross-section trapezoidal shape. The laminating of the vertical bias layer 7 and the current lead layer 8 is carried out to the both sides of the inclination part of said layered product S4 like previous structure, when said vertical bias layer 7 is magnetized by illustration X1 direction and the 180-degree opposite direction, a bias field acts on the free magnetic layer 43, and magnetization of the free magnetic layer 43 is arranged with illustration X1 direction and the 180 outlines opposite direction.
[0149] The nonmagnetic interlayer 42 intervenes between the 1st free magnetic layer 43 shown in drawing 13 and drawing 14 , and the 2nd free magnetic layer 41, and magnetization of said 1st free magnetic layer 43 and magnetization of the 2nd free magnetic layer 41 are [of the opposite direction] anti-parallel 180 degrees by the switched connection field (RKKY interaction) generated between said 1st free magnetic layer 43 and the 2nd free magnetic layer 41 (ferry condition). With the spin bulb mold magneto-resistive effect component GMR 4 shown in drawing 14 , the thickness tF1 of the 1st free magnetic layer 43 is formed more greatly than the thickness tF2 of the 2nd free magnetic layer 41, for example. And the magnetic thickness (Ms-tF1) of said 1st free magnetic layer 43 If it is set up so that it may become larger than the magnetic thickness (Ms-tF2) of the 2nd free magnetic layer 41, and a bias field is given to illustration X1 direction and a 180-degree opposite direction from the vertical bias layer 7 Magnetization of the 1st free magnetic layer 43 with large magnetic thickness (Ms-tF1) is influenced of said bias field. Step is kept with illustration X1 direction and a 180 outlines opposite direction, and magnetization of the 2nd free magnetic layer 41 with small magnetic thickness (Ms-tF2) is arranged in the direction near illustration X1 direction by the switched connection field (RKKY interaction) with said 1st free magnetic layer 43. Moreover, as for the nonmagnetic interlayer 42 who intervenes in this invention between the 1st free magnetic layer 43 and the 2nd free magnetic layer 41, it is desirable to be formed with one sort or two sorts or more of alloys among Ru, Rh, Ir, Cr, Re, and Cu.
[0150] In addition, in this operation gestalt, the thickness tF1 of the 1st free magnetic layer 43 may be formed smaller than the thickness tF2 of the 2nd free magnetic layer 41, and the magnetic thickness (MS-tF1) of said 1st FURI 1 magnetic layer 43 may be set up smaller than the magnetic thickness (MS-tF2) of the 2nd free magnetic layer 41. In the case of Perilla frutescens (L.) Britton var. crispa (Thunb.) Decne., the direction of the magnetization of the 1st free magnetic layer 43 which the direction of the magnetization of the 2nd free magnetic layer 41 made into big magnetic thickness made small magnetic thickness toward X1 direction and the 180 outlines opposite direction merely turns into a direction near X1 direction.
[0151] However, also in a **** 4 operation gestalt, when the detection current field Hj acts, the free magnetic layer 41, the direction of magnetization of 43, and the fixed magnetic layer 49 and the direction of magnetization of 47 serve as the same angular relation-ship as what is guessed from drawing 3 R> 3. However, since a free magnetic layer consists of two-layer structure of the 1st free magnetic layer 43 and the 2nd free magnetic layer 41 with a **** 4 operation gestalt It becomes in the direction which corresponds towards the magnetization Mf of the free magnetic layer 4 in case the direction of magnetization of the 1st free magnetic layer 43 with big magnetic thickness is said 3rd operation gestalt. It becomes the direction and 180-degree opposite direction of the magnetization Mf of the free magnetic layer 4 in case the direction of magnetization of the 2nd free magnetic layer 41 with small magnetic thickness is the 3rd operation gestalt.
[0152] If the external magnetic field from a magnetic-recording medium invades from illustration Y to the spin bulb mold magneto-resistive effect component GMR 4 shown in drawing 14 , magnetization of said 1st free magnetic layer 43 and the 2nd free magnetic layer 41 will rotate in response to the effect of said external magnetic field, maintaining a ferry condition. And with the relation between the magnetization direction of the 1st free magnetic layer 43 which **** to **R/R, and fixed magnetization of the 2nd fixed magnetic layer 47, electric resistance changes and the signal of an external magnetic field is detected. Since the free magnetic layers 41 and 43 are single-domain-ized by the bias field which the vertical bias layer 7 makes act in that case, a smooth resistance change which does not produce a Barkhausen noise can be obtained.
[0153] In the structure of a **** 4 operation gestalt, about other effectiveness, it is equivalent to the spin bulb mold magneto-resistive effect component of the previous 1st operation gestalt, when the detection current field Hj acts, it is constituted so that the free magnetic layer 43 and the sense of magnetization of the 1st fixed magnetic layer 49 or the 2nd fixed magnetic layer 47 and the sense of magnetization of 41 may cross at right angles, and thereby, asymmetry can be decreased.
[0154]
[Example] It examined using the spin bulb mold magneto-resistive effect component of the following laminated structures. Al Chick A substrate / alumina substrate layer (aluminum2O3-TiC) a (aluminum2O3 substrate layer) / lower shielding layer; -- amorphous Co-Nb-Zr alloy film; -- thickness 1x10-6m / lower gap layer (500A in 2O3 layers [of aluminum] : thickness) / substrate layer; -- Ta (30A in thickness) / antiferromagnetism layer ;P tMn

(300A in thickness) / fixed magnetic layer [of ** a 1st]; -- Co (15A in thickness) / nonmagnetic interlayer; Ru (8A in thickness), the 2nd fixed magnetic layer; Co (20A in thickness) / nonmagnetic conductive layer; Cu As opposed to the layered product of the laminated structure of a permalloy (nickel-Fe alloy; 3x10 to 6 m thickness) (27Ain thickness)/-- free -- magnetic layer;Co(10A in thickness)+NiFe (50A in thickness) / protective layer; -- Ta (30A in thickness) / up gap layer (850A in 2O3 layers [of aluminum] : thickness) / up shielding layer; -- When the spin bulb mold magneto-resistive effect component of the structure which carried out the laminating of a vertical bias layer (300A in a Co-Pt alloy, thickness) and the current lead layer (1200A in Cr layer, thickness) to the both sides was manufactured, this invention approach was applied.

[0155] The manufacture approach previously explained based on drawing 7 was enforced, and the spin bulb mold magneto-resistive effect component of the above-mentioned laminated structure was manufactured. First, the sputtering system was used on the wafer substrate which consists of Al Chick (aluminum2O3-TiC) / an aluminum2O3 substrate layer, and the lower shielding layer of 1x10 to 6 m thickness was formed. Membranes were formed so that it might become the thickness which used the sputtering system, formed the lower gap layer (alumina layer) with a thickness of 500A on this wafer substrate, and formed Ta substrate layer and the antiferromagnetism layer on it, next indicated previously the 1st fixed magnetic layer, a nonmagnetic interlayer, the 2nd fixed magnetic layer, and a nonmagnetic conductive layer one by one. Moreover, when said 1st fixed magnetic layer and the 2nd fixed magnetic layer were formed, field 8 kA/m was impressed in the direction which crosses separately 90 degrees to the truck cross direction. Then, the free magnetic layer was formed impressing the 1st field in the 1st direction which forms a nonmagnetic conductive layer, and meets crosswise [truck] continuously, and the protective layer was further formed with the sputtering system.

[0156] Next, it is the 2nd field H2 (1st heat treatment (the 1st annealing treatment) annealed after heating to the 1st heat treatment temperature (523K;250 degree C) is performed impressing 400 kA/m in field strength.) to the direction DA which intersects perpendicularly to the truck cross direction as shown in drawing 7 B to the 2nd direction D2 which made only the include angle theta (theta= 10 degrees) incline. By this 1st heat treatment, the PtMn alloy which constitutes an antiferromagnetism layer is ordered-structure-ized from unordered structure, the magnetic switched connection force is demonstrated, and the sense of magnetization of the 1st fixed magnetic layer can be fixed in the 2nd direction D2. Moreover, while impressing the 2nd field H2 in the case of this 1st heat treatment, although both turn to magnetization of the 1st fixed magnetic layer and the 2nd fixed magnetic layer in the 2nd direction D2 If the 2nd field H2 is removed, the sense of magnetization of the 2nd fixed magnetic layer will be [the sense of magnetization of the 1st fixed magnetic layer and / of the opposite 180 degree sense] anti-parallel by the magnetic switched connection field (RKK interaction) which the 1st fixed magnetic layer makes act on the 2nd fixed magnetic layer.

[0157] Then, annealing treatment heated to 473K (200 degrees C) was performed impressing the 1st field H1 smaller than the 2nd previous field H2 in the 1st direction D1 parallel to the truck cross direction, and the sense of the uniaxial anisotropy of a free magnetic layer was arranged crosswise [truck]. Next, after forming a vertical bias layer and an electrode layer by the lift-off method, an up gap and 850A of alumina layers were formed by the spatter. Next, the up shielding layer of a permalloy (nickel-Fe alloy) was formed with plating, after that, it continued at record gap formation and the coil was formed. Although an up core is formed on this coil, the wrap need is by insulating resin about a coil before that. In this process, annealing treatment which heats this whole layered product for 60 minutes to 473K (200 degrees C) was performed. This annealing treatment is equivalent to the temperature and the processing time in the case of stiffening the thermosetting resin for a coil section insulation used when manufacturing the practical thin film magnetic head equipped with the magnetic-induction mold write head shown in drawing 4 thru/or drawing 6 . The direction of the uniaxial anisotropy of a free magnetic layer, a lower shielding layer, and an up shielding layer will vary by this heat treatment.

[0158] Next, impressing the 3rd field H3 (it being 80kA/m in field strength) smaller enough than the 2nd previous field H2 in the direction D1 parallel to the truck cross direction, 2nd heat treatment annealed after heating to 473K (200 degrees C) is performed, and the direction of the uniaxial anisotropy of a free magnetic layer and lower shielding layer and an up shielding layer is arranged in the parallel direction D1 to the truck cross direction. Next, the spin bulb mold magneto-resistive effect component was obtained by impressing the 4th field H4 in the 4th direction D4 parallel to the truck cross direction, and magnetizing a hard bias layer in the 4th direction.

[0159] Drawing 15 is drawing showing the measurement result of the anisotropy field of the measurement result of the anisotropy field of an up shielding layer, and the up shielding layer after heat treatment assumed to be added at the time of write head formation was performed, and the measurement result of the anisotropy field of the up shielding layer after said 2nd heat treatment was performed in a condition [having formed membranes on a wafer] in two up shielding stratification finishing wafers obtained by the above manufacture approach. Although the measurement result shown in drawing 15 shows that the value of the anisotropy field of an up shielding layer is once decreasing by heat treatment at the time of write head formation, it turns out that it has recovered in the magnitude of the original anisotropy field by 2nd heat treatment.

[0160] In the wafer after the up shielding stratification of two sheets from which drawing 16 was obtained by the above manufacture approach In a condition [having formed membranes on a wafer] The measurement result of the anisotropy angular dispersion of an up shielding layer, It is drawing showing the measurement result of the anisotropy angular dispersion of the up shielding layer after heat treatment assumed to be added at the time of write head formation was performed, and the measurement result of the anisotropy angular dispersion of the up shielding layer after said 2nd heat treatment was performed. With alpha 90 shown as anisotropy angular dispersion in drawing 16 It is what measures the include angle of said property in case 90% of fields made less than into the specific include angle to the direction of the meant easy axis which is made into the purpose on the whole wafer surface in which the up shielding layer was formed exists to the whole wafer surface. It means that the field considered as the gap of less than 5 times to the direction of the meant easy axis which the anisotropy angular dispersion alpha 90 makes the purpose in 5 times exists at 90% of rate of surface ratio to the whole wafer surface. A paraphrase means that 10% of fields shifted from the direction which the gap of the easy axis in a local part meant on the whole wafer surface 5 times or more exists.

[0161] Although the angular dispersion of an anisotropy is 5 times, if annealing treatment is performed in the condition [having formed the up shielding layer by plating] from the measurement result shown in drawing 16 at the time of write head formation, the angular dispersion of an anisotropy becomes large and, as for the angular dispersion of an anisotropy, falling is [after a subsequent final process] distinct. If it puts in another way, according to the previous manufacture approach, in whole wafer surface level, anisotropy distribution of the direction of an easy axis can be suppressed.

[0162] Drawing 17 is for simplified schematic to explain local fluctuation of the direction of the easy axis shown in drawing 16. That in which the direction a of an easy axis is ready to some extent in the condition [having plated the up shielding layer, as shown in drawing 17 A] As shown in drawing 17 B, the direction of an easy axis shows turbulence and that the turbulence is modified in a final process and it is prepared still better rather than the direction of the anisotropy of an easy axis with plating at the time of annealing treatment at the time of write head formation.

[0163] Since the magnetic conditions of the perimeter at the time of the conditions of magnetization of an up shielding layer whenever it writes magnetic information in a magnetic-recording medium by the write head differing, and a read head reading the magnetic information on a magnetic-recording medium in response to effect by this stop becoming fixed when the magnetic head manufactures with the condition that for example, an up shielding layer shows drawing 17 B here, it has a possibility that the read-out precision of magnetic information may fall, such as changing a playback output. Since there is no fluctuation in the directivity of magnetization of an up shielding layer even if it writes in a magnetic signal repeatedly by the write head when the sense of the easy axis of an up shielding layer is ready, as this point is shown in drawing 17 C, the condition of an up shielding layer does not have a bad influence on the read-out precision of a spin bulb mold magneto-resistive effect component. Moreover, that the angular dispersion of an anisotropy is small on the whole wafer surface means that angular dispersion of the anisotropy of an up shielding layer cannot be easily influenced due to the formation location of a wafer, and that the yield in the case of manufacturing many spin bulb mold magneto-resistive effect components from one wafer can be improved if it puts in another way, when manufacturing many spin bulb mold magneto-resistive effect components from one wafer.

[0164] Drawing 18 is what shows the value of the coercive force of the free magnetic layer for every process in the previous manufacture approach. The place which measured the coercive force in the direction which intersects perpendicularly with the truck cross direction of a free magnetic layer after forming a free magnetic layer to each wafer using three wafers, As for the coercive force of the free magnetic layer measured after having set in three samples, a gap being also the coercive force below 80 A/m order, giving various processes by said approach to this wafer and passing through annealing at the time of write head formation, it is distinct to have gone up to 160 - 240 A/m. Furthermore, since the coercive force of the free magnetic layer after the 2nd heat treatment fell to level lower than immediately after membrane formation, it is clear that its the effectiveness of this invention is acquired.

[0165] Drawing 19 is what shows the result of having measured the value of the anisotropy field of the free magnetic layer for every process of the previous manufacture approach by three wafer samples. In the annealing treatment at the time of write head formation, an anisotropy field falls [what was an anisotropy field around 3.5 degrees] after membrane formation, and it sets after the 2nd heat treatment. It is distinct that the anisotropy field of a free magnetic layer goes up, and it is clear that it is controllable after the 2nd heat treatment to the measurement result after membrane formation and the value before and behind 320 A/m practically equal.

[0166] Drawing 20 is for simplified schematic to explain fluctuation of the direction of the easy axis of a free magnetic layer, and as that in which the direction a of an anisotropy field is ready shows drawing 20 B, in the condition [having formed each class, as shown in drawing 20 A], the direction a of the anisotropy field of a free magnetic layer shows that the direction of the anisotropy field of a free magnetic layer is prepared after turbulence and the 2nd heat treatment at the time of annealing treatment at the time of write head formation.

[0167] Drawing 21 shows the result of having measured the sense of the magnetization for every flat-surface location of each fixed magnetic layer by the micro magnetic simulation, in the condition that the vertical bias field from a hard bias layer acted rightward from left-hand side to the 1st fixed magnetic layer of a layered product and the 2nd fixed magnetic layer which were manufactured previously. The arrow head has indicated for every location what kind of effect the direction of the magnetization for every location of the 2nd fixed magnetic layer and the direction of the magnetization for every location of the 1st fixed magnetic layer receive from a hard bias layer in drawing 21 in the condition that the vertical bias field acted, to the 2nd fixed magnetic layer. Moreover, in the structure of this layered product, the synthetic switched connection field Hex was carried out in 72kA/m.
[0168] In this structure, magnetization of the 2nd fixed magnetic layer with mainly big magnetic thickness receives effect in the sense of magnetization in response to a hard bias field, and the sense of magnetization of the 1st fixed magnetic layer ****s on the other side 180 degrees to the sense of magnetization of the 2nd fixed magnetic layer influenced [this] at the opposite sense. Especially, in the 2nd fixed magnetic layer, the sense of magnetization is greatly shifted from ten slant in response to the effect of magnetization of a circumference part of a hard bias layer, and the sense of magnetization of the periphery part of the 1st fixed magnetic layer is greatly shifted from across [ten] regular according to the sense of these magnetization of the periphery section of the 2nd fixed magnetic layer that carried out the include-angle gap greatly.
[0169] Although the function as a spin bulb mold magneto-resistive effect component can fully be obtained also in the condition that it is shown in drawing 21 For the purpose of making higher stability as a spin bulb mold magneto-resistive effect component In order to arrange more completely the sense of magnetization in the periphery parts of the 2nd fixed magnetic layer and the 1st fixed magnetic layer, it turns out that it is desirable to make a synthetic switched connection field (Hex) into a bigger value than 72 kA/m. In order to see from the condition of the inclination of the fixed magnetic layer shown in this drawing 21 and to lessen dispersion in the sense of magnetization in the periphery part of the 2nd fixed magnetic layer as much as possible, allowances are seen and it is thought desirable to make a synthetic switched connection field (Hex) into a bigger value than 96 kA/m.
[0170] While magnetization considers as the other side in the direction in which it is influenced by the hard bias field in the periphery part of a fixed magnetic layer here, and the field of a hard bias layer acts Since the 2nd fixed magnetic layer is making exchange anisotropy act so that it may incline to this and an opposite direction, turbulence of the sense of magnetization emphasizes greatly by this frustration -- having (spin FUROPPU being started) -- Since it will be in the condition that it will have the field where the directions of magnetization differ in a fixed magnetic layer, and two or more magnetic domains were formed in the fixed magnetic layer so to speak Since resistance change becomes that it is fully hard to be discovered and the detection precision of the leakage field from a record medium falls when the direction of magnetization of a free magnetic layer rotates, it is not desirable. Moreover, when the field where the inclination of this magnetization was emphasized exists, there is also a possibility that the stability as a spin bulb mold magneto-resistive effect component may be spoiled. Moreover, with the periphery part of a fixed magnetic layer, the location nearest to the magnetic-recording medium near the ABS side is included in the thin film magnetic head. In the part nearest to a magnetic-recording medium, it will be said that turbulence of magnetization of a fixed magnetic layer is emphasized under the effect of an anti-field, and especially effect is considered to be a large thing by the stability as a spin bulb mold magneto-resistive effect component. For this reason, holding down the tilt angle theta of a fixed magnetic layer to 10 or less degrees most preferably 15 or less degrees 30 or less degrees also has the purpose which suppresses such instability besides suppressing loss of power.
[0171]
[Effect of the Invention] In the spin bulb mold magneto-resistive effect component of a configuration of according to this invention explained in full detail above, having the free magnetic layer, the 1st fixed magnetic layer, and the 2nd fixed magnetic layer which the sense of magnetization is made to cross and are prepared, and passing a detection current When a detection current field is made to act to a free magnetic layer in the condition of having passed the detection current and having made the detection current field acting and the direction of magnetization of a free magnetic layer is made to incline Since the include-angle theta inclination of was done to the direction of fixed magnetization of the 1st fixed magnetic layer and the 2nd fixed magnetic layer so that it might become close to a rectangular condition about the direction of magnetization of a free magnetic layer While resistance change in the condition of not acting with the condition that the external magnetic field from a magnetic-recording medium acted can be enlarged, the asymmetry used as the index of the imbalance property of an output can be decreased. Asymmetry can be decreased without affecting an output, after making an output high enough by making theta into 30 or less degrees 2 times or more whenever [said tilt-angle]. Asymmetry can be decreased further, without affecting an output by making theta into 15 or less degrees 3 times or more whenever [tilt-angle], and asymmetry can be decreased further, without affecting an output because it takes 3 times or more for 10 or less degrees.
[0172] When the 1st fixed magnetic layer and the 2nd fixed magnetic layer are prepared, The magnetic switched

connection force received from an antiferromagnetism layer after making the direction of magnetization of the 1st fixed magnetic layer and the 2nd fixed magnetic layer into an anti-parallel condition by making magnetic thickness of the 2nd fixed magnetic layer larger than the 1st fixed magnetic layer can be demonstrated efficiently, and the fixed force of magnetization can be made to act strongly. While being able to demonstrate strongly the force which carries out stable maintenance of the sense of magnetization of the 1st fixed magnetic layer and the 2nd fixed magnetic layer, resistance rate-of-change deltaR/R can also be maintained at a big value. It is desirable to use a XMn alloy and a XMnX' alloy as a component of the antiferromagnetism layer used since magnetization of the 1st fixed magnetic layer and magnetization of the 2nd fixed magnetic layer are fixed strongly, blocking temperature is higher than the conventional ingredients, such as FeMn, by using these alloys, and the fixed force of the magnetization stabilized more at the elevated temperature can be acquired.

[0173] Moreover, if an antiferromagnetism layer considers as 96 or more kA/m as a value of the synthetic switched connection field made to act on the 1st fixed magnetic layer and the 2nd fixed magnetic layer, the spin bulb mold magneto-resistive effect component which has the stable fixed magnetization which cannot be easily influenced towards magnetization due to the vertical bias field which a vertical bias layer makes act can be obtained.

[0174] Next, according to the manufacture approach of this invention As opposed to the direction which intersects perpendicularly crosswise [truck] to an antiferromagnetism layer in case the spin bulb mold magneto-resistive effect component of the structure which divided the fixed magnetic layer to two-layer is manufactured The include-angle theta inclination of the direction of magnetization of a fixed magnetic layer can be beforehand done from the direction which intersects perpendicularly crosswise [truck] by performing 1st heat treatment, impressing the 2nd field of which the include-angle theta inclination was done. The sense of magnetization can be adjusted so that a fixed magnetic layer and a free magnetic layer may cross at an angle of the purpose in the condition that the detection current field acted by this. Therefore, when making a detection current field act by this invention approach and reading the magnetic information from a magnetic-recording medium, the spin bulb mold magneto-resistive effect component which has little high read-out precision of asymmetry, with a high output having can be obtained.

[0175] Next, if 2nd heat treatment is performed after said 1st heat treatment and the direction of the uniaxial anisotropy of a free magnetic layer is arranged crosswise [truck] in the 2nd heat treatment Even if the sense of the uniaxial anisotropy of a free magnetic layer or a vertical shielding layer is confused according to the heat treatment process for giving the heat treatment process for forming the induction type magnetic head for record, and forming the induction type magnetic head for record between the 1st heat treatment and the 2nd heat treatment Since the sense of the uniaxial anisotropy of a free magnetic layer or a vertical shielding layer can be again arranged at the time of the 2nd heat treatment, the spin bulb mold magneto-resistive effect component which arranged the sense of the uniaxial anisotropy of a free magnetic layer or a vertical shielding layer can be obtained.

[0176] Moreover, it sets to the manufacture approach of this invention. A fixed magnetic layer The spin bulb mold magneto-resistive effect component of the structure divided to two-layer After demonstrating the switched connection field by the antiferromagnetism layer by performing 1st heat treatment and fixing the sense of magnetization of the 1st fixed magnetic layer and the 2nd fixed magnetic layer, impressing the 2nd field in the direction which intersects perpendicularly with the truck cross direction in case it manufactures, Since the include-angle theta inclination of the sense of magnetization of a fixed magnetic layer can be done by performing 2nd heat treatment from the direction which intersects perpendicularly crosswise [truck], forming a vertical bias layer, preparing the sense of the uniaxial anisotropy of a free magnetic layer, and impressing the 3rd field subsequently The sense of magnetization can be adjusted so that a fixed magnetic layer and a free magnetic layer may cross at an angle of the purpose in the condition that the detection current field acted. Therefore, when making a detection current field act by this invention approach and reading the magnetic information from a magnetic-recording medium, the spin bulb mold magneto-resistive effect component which has little high read-out precision of asymmetry, with a high output having can be obtained.

[0177] Next, if the direction of the uniaxial anisotropy of a free magnetic layer is arranged crosswise [truck] while performing 2nd heat treatment after said 1st heat treatment and doing the include-angle theta inclination of the sense of magnetization of a fixed magnetic layer in the 2nd heat treatment The heat treatment process for forming the induction type magnetic head for record between the 1st heat treatment and the 2nd heat treatment is given. Even if the sense of the uniaxial anisotropy of a free magnetic layer or a vertical shielding layer is confused according to the heat treatment process for forming the induction type magnetic head for record Since the sense of the uniaxial anisotropy of a free magnetic layer or a vertical shielding layer can be again arranged at the time of the 2nd heat treatment, the spin bulb mold magneto-resistive effect component which arranged the sense of the uniaxial anisotropy of a free magnetic layer or a vertical shielding layer can be obtained.

[0178] A XMn alloy and a XMnX' alloy can be used as an antiferromagnetism layer used in said each manufacture approach, if it is these alloys, it can be made to be able to change with heat treatments from the condition of unordered structure to the condition of ordered structure, and the direction of magnetization of a fixed magnetic

layer can be arranged in the direction of a field by impressing a field in the specific direction at the time of this heat treatment.

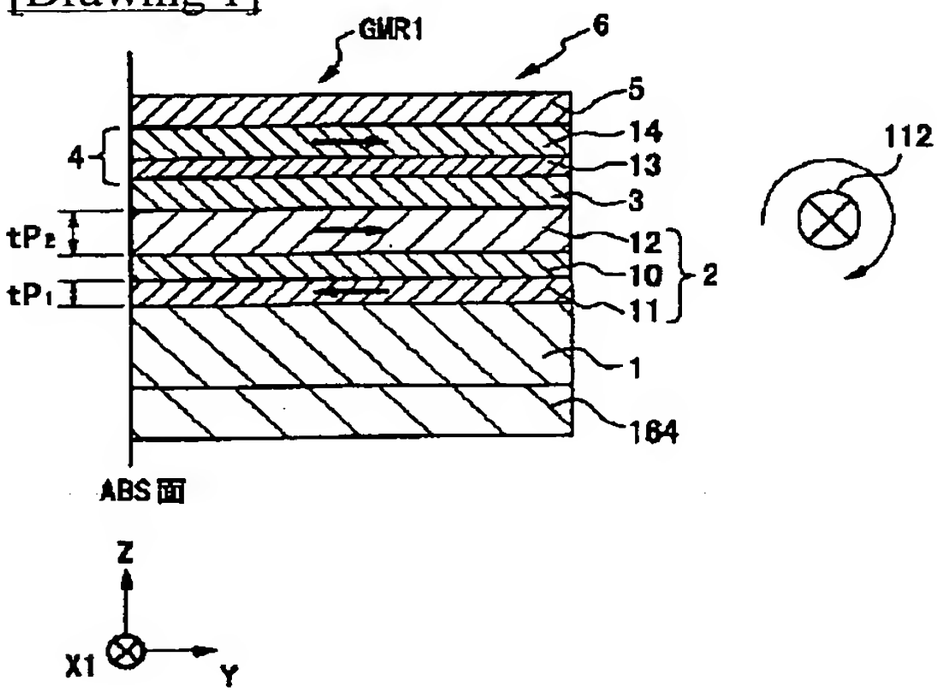
[Translation done.]

* NOTICES *

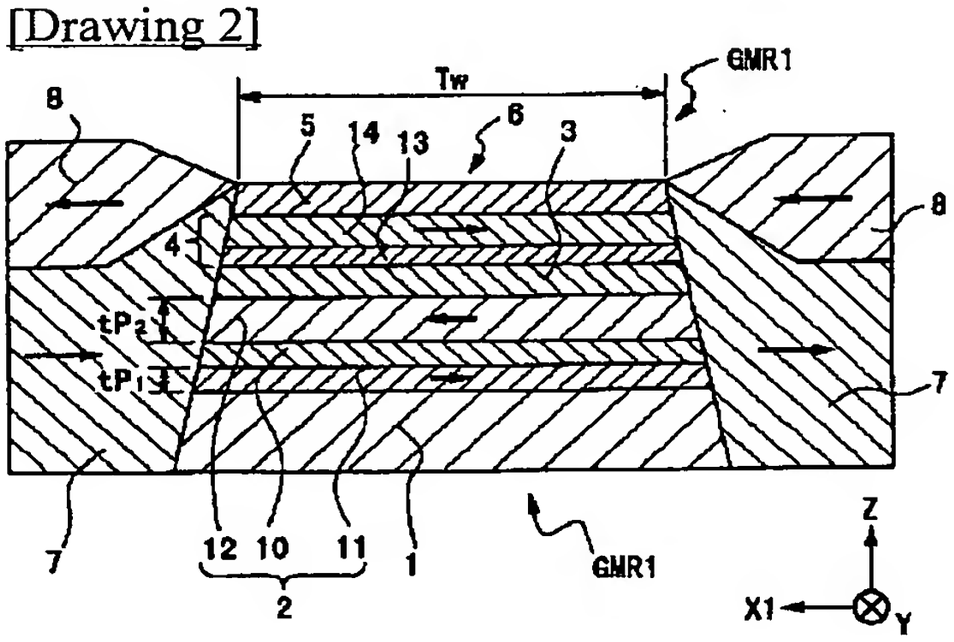
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]



[Drawing 2]



[Drawing 3]

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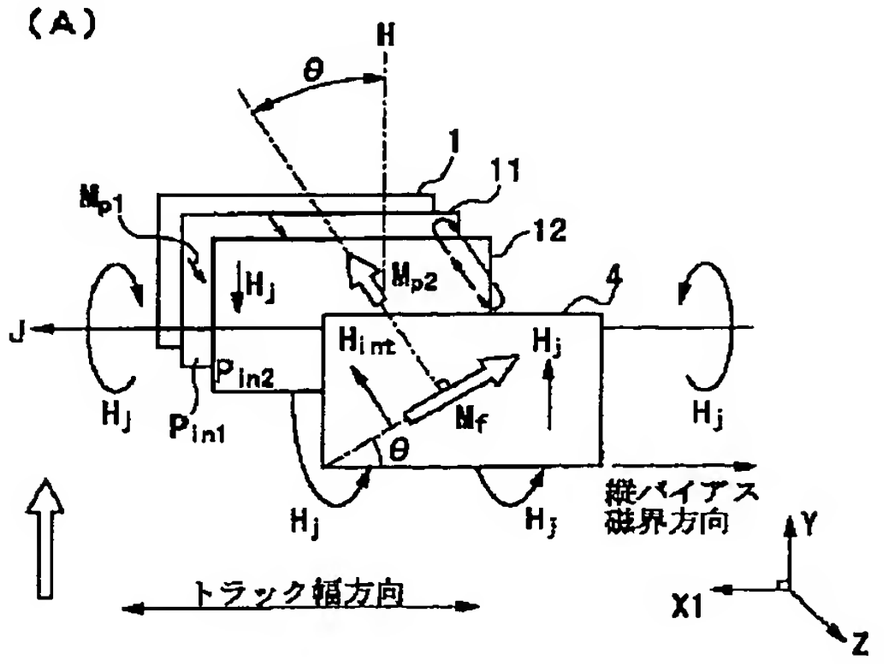
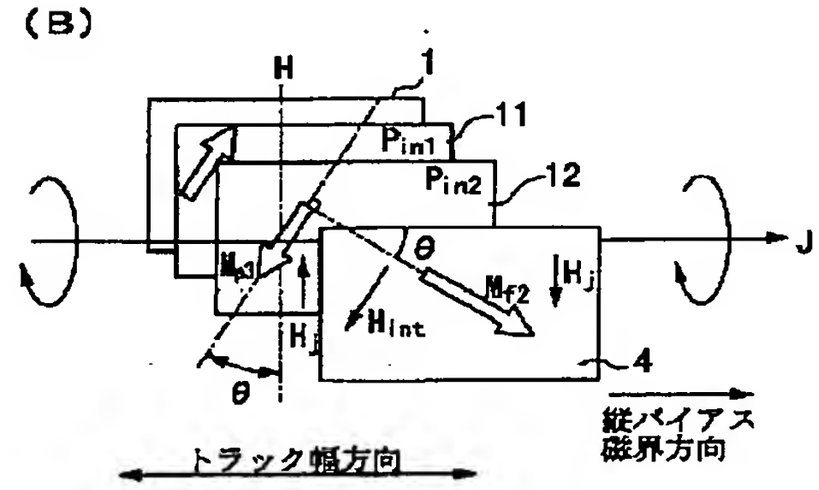
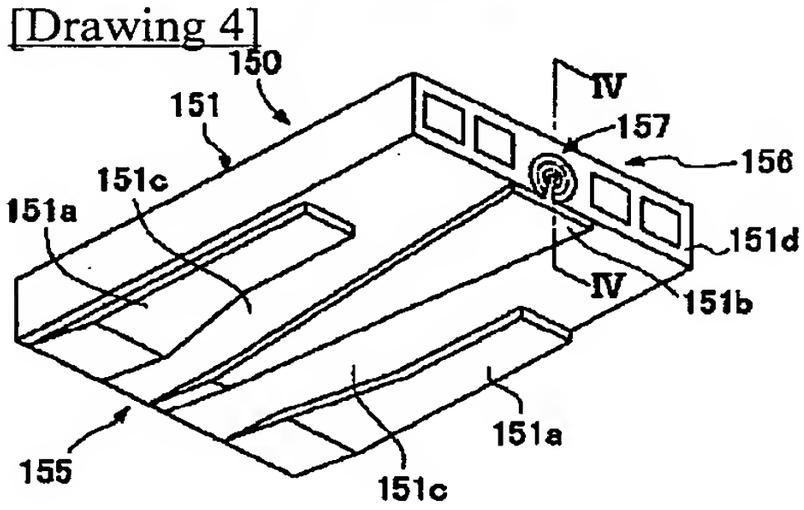


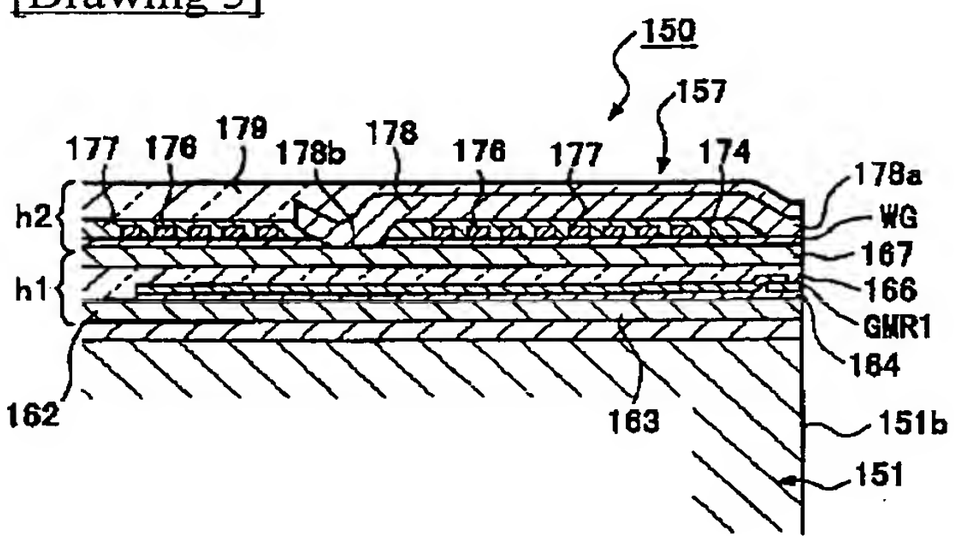
(B)



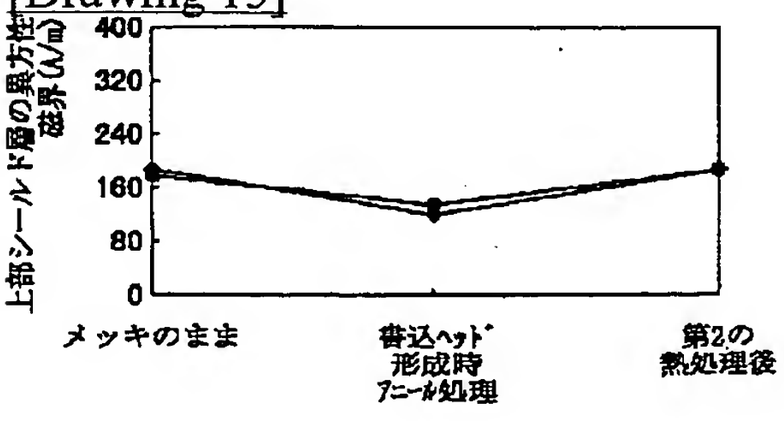
[Drawing 4]



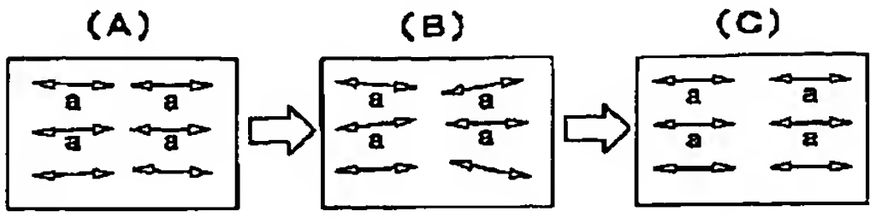
[Drawing 5]



[Drawing 15]



[Drawing 17]



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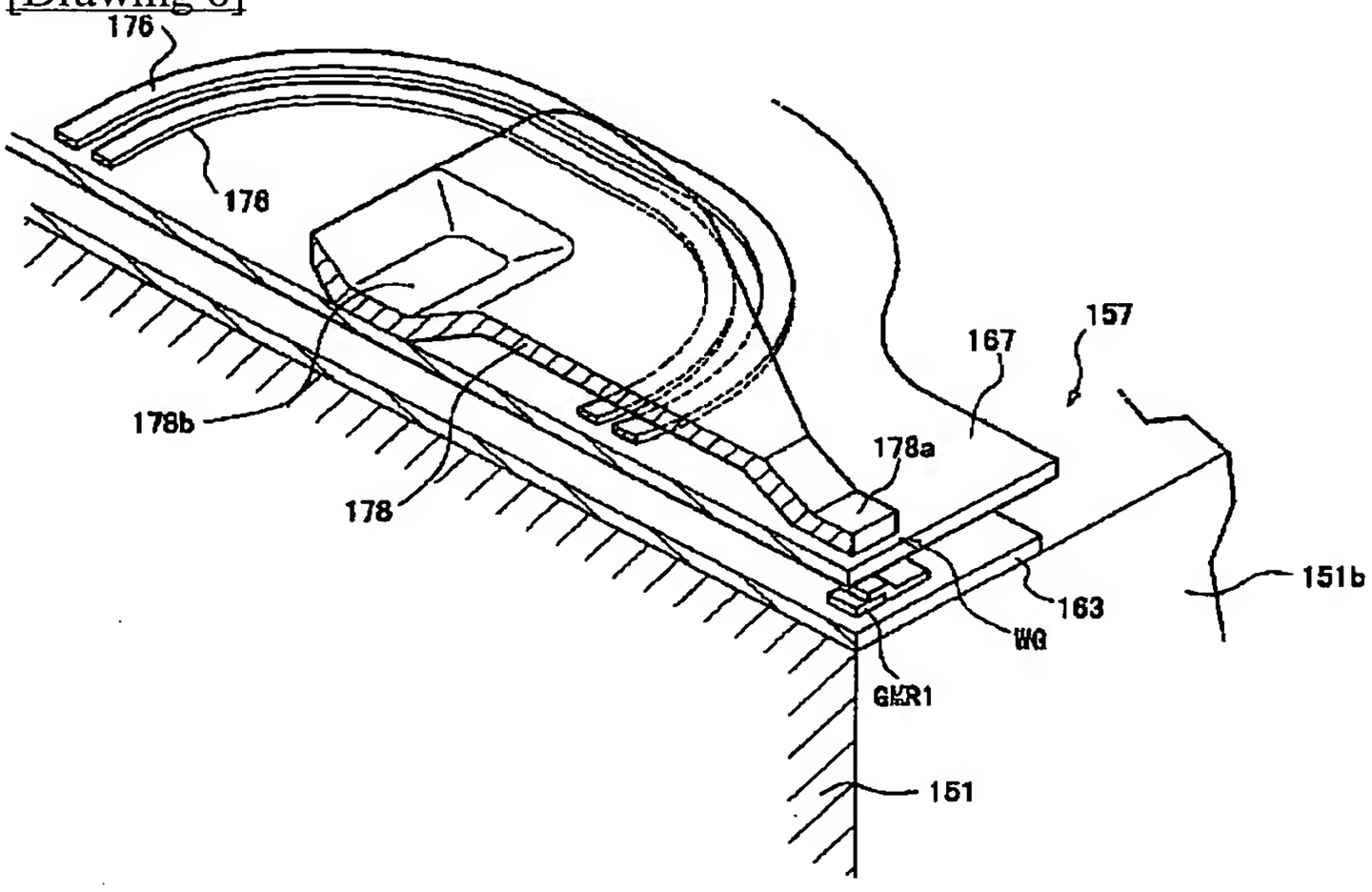

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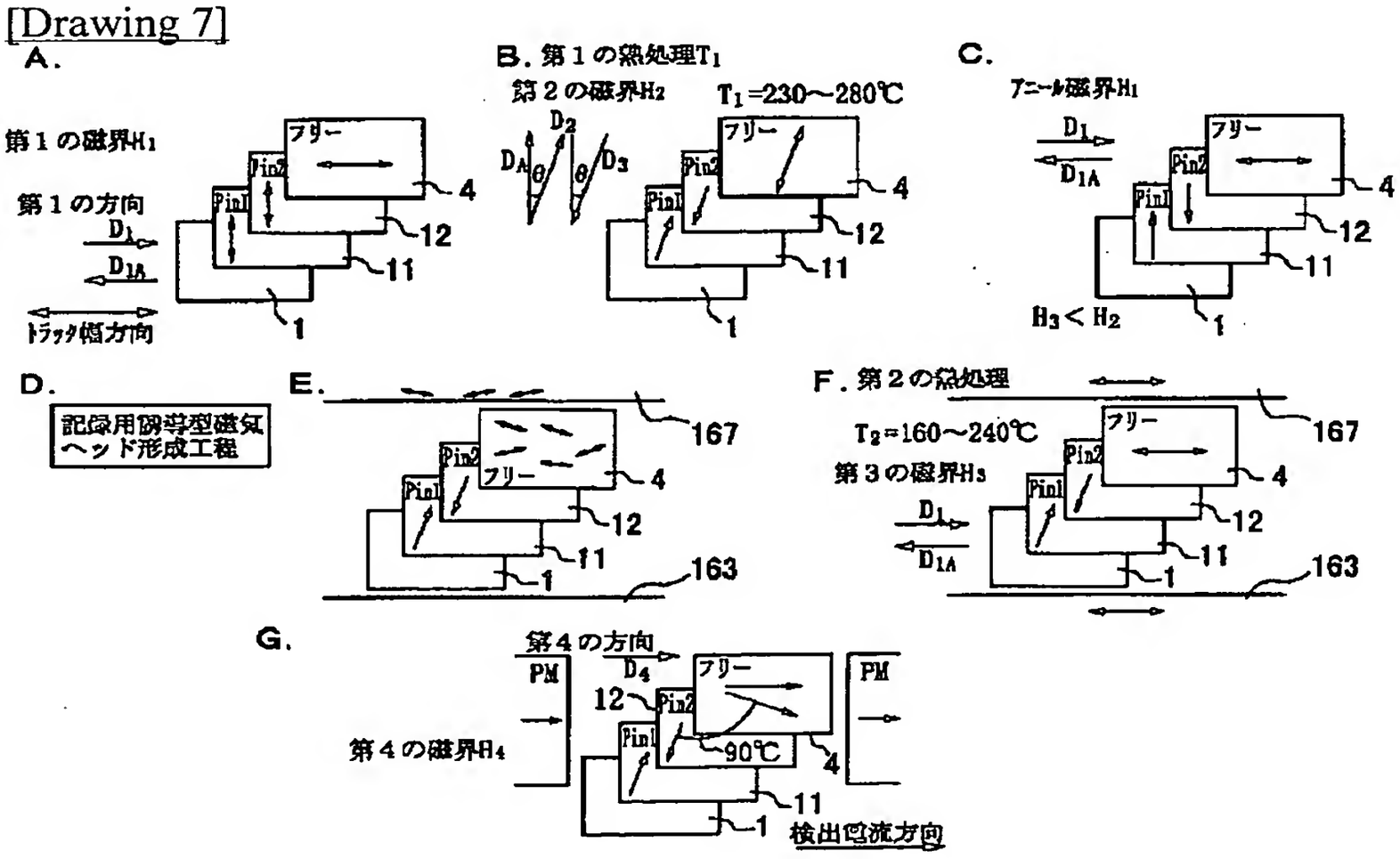

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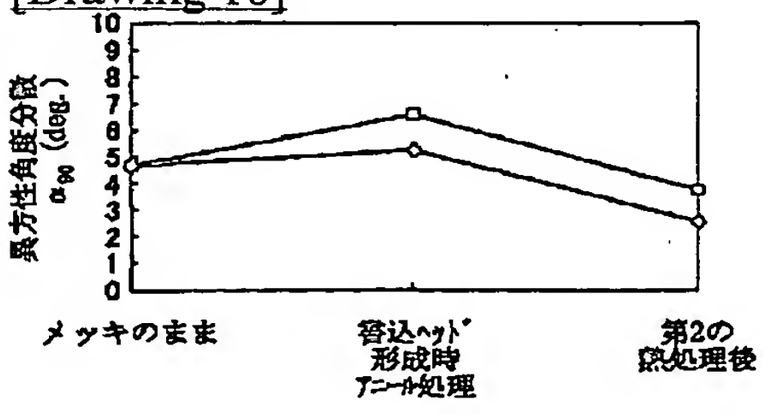
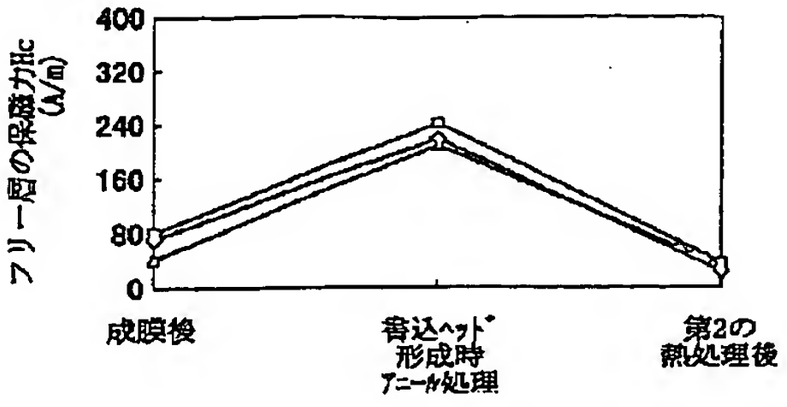
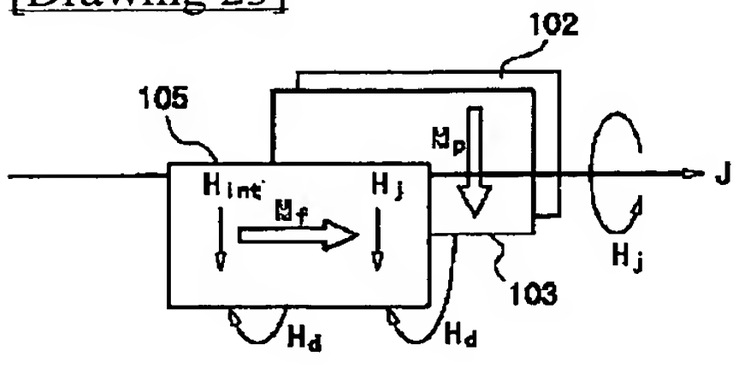


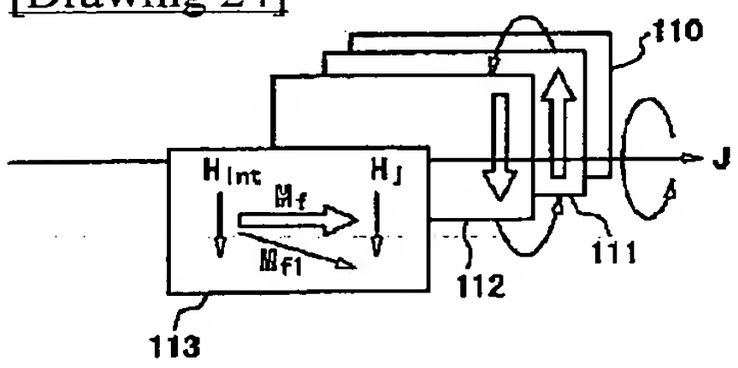
[Drawing 18]



[Drawing 23]



[Drawing 24]



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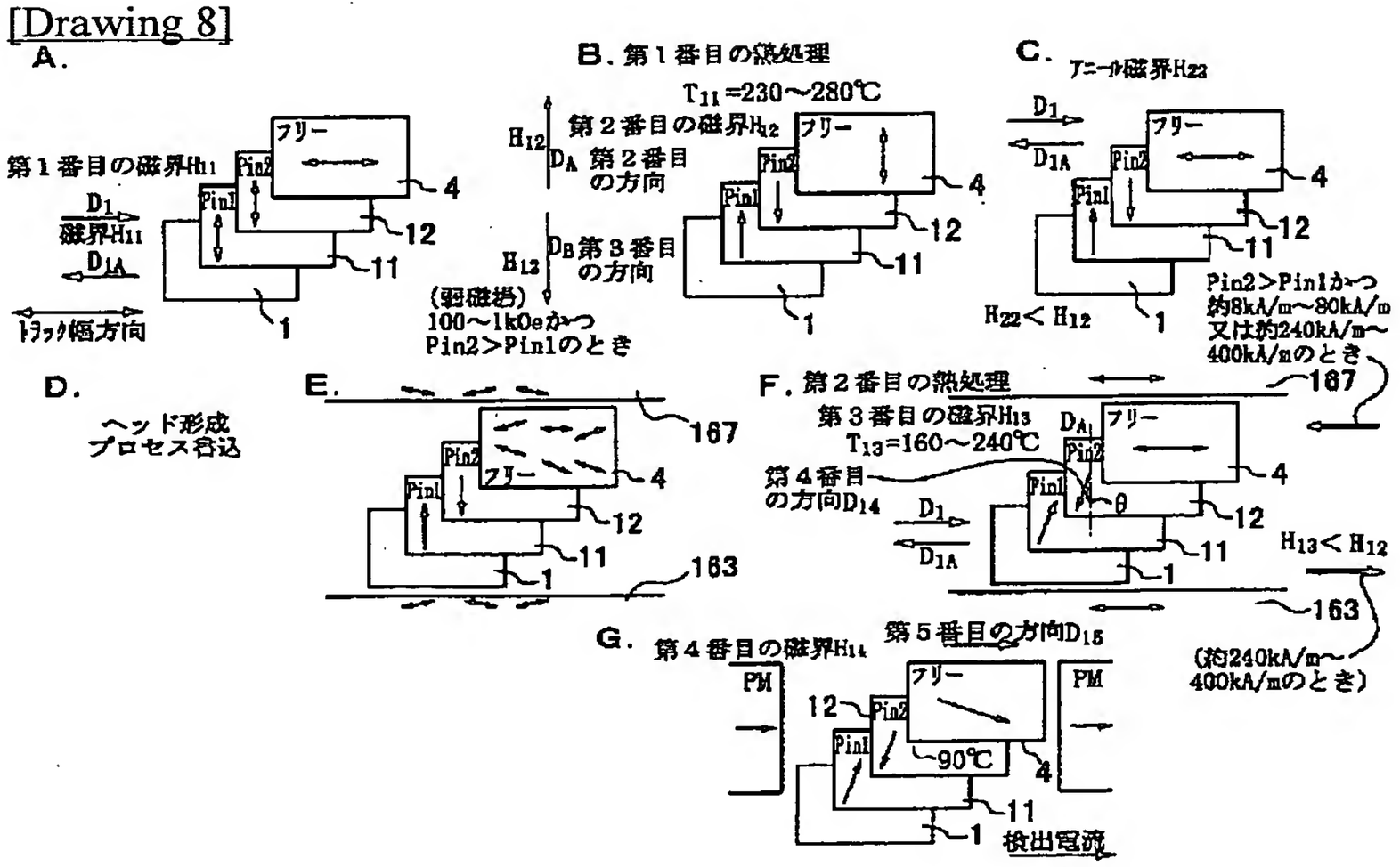

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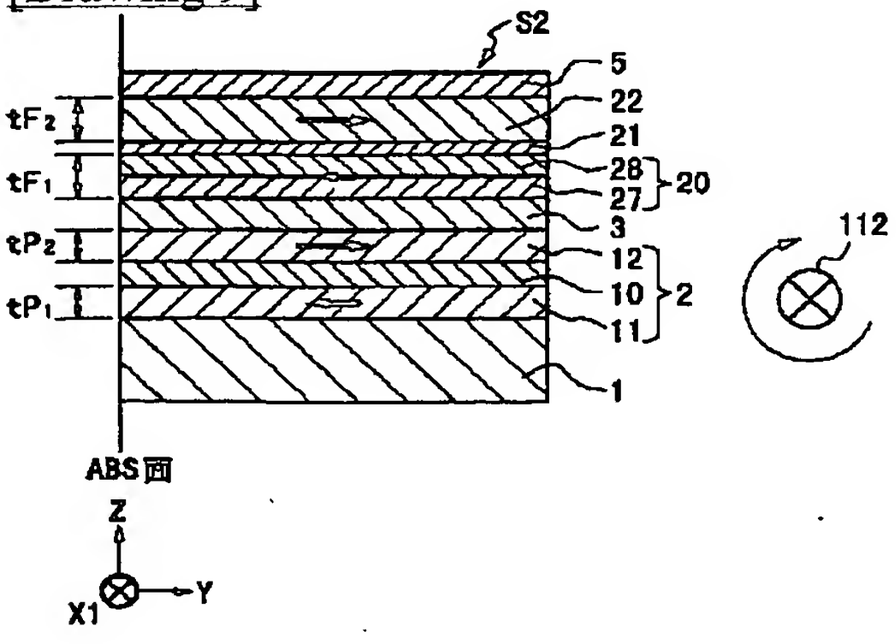

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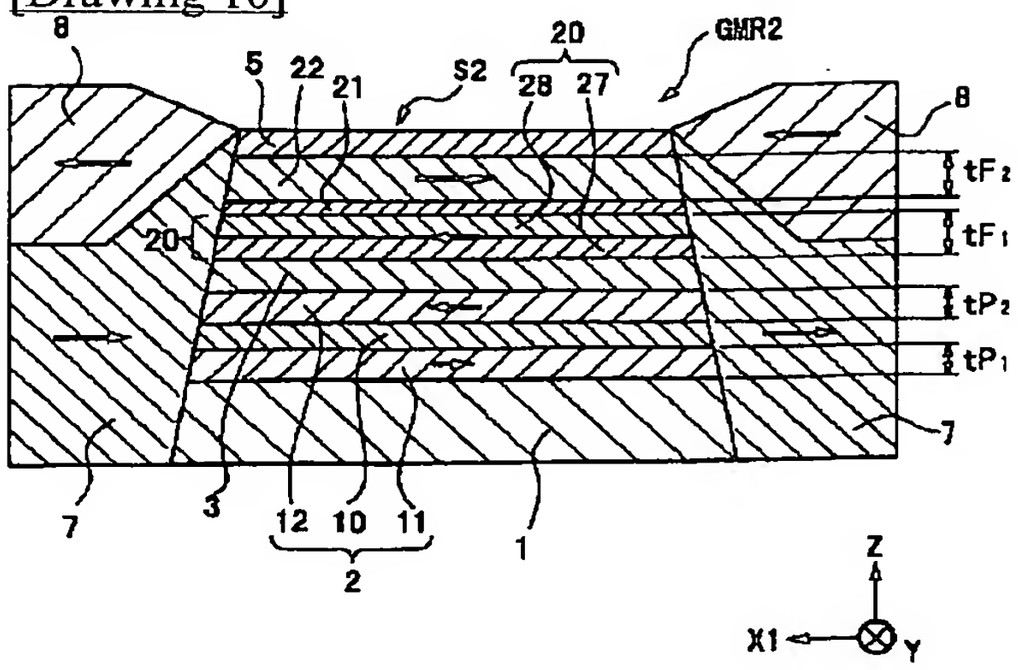

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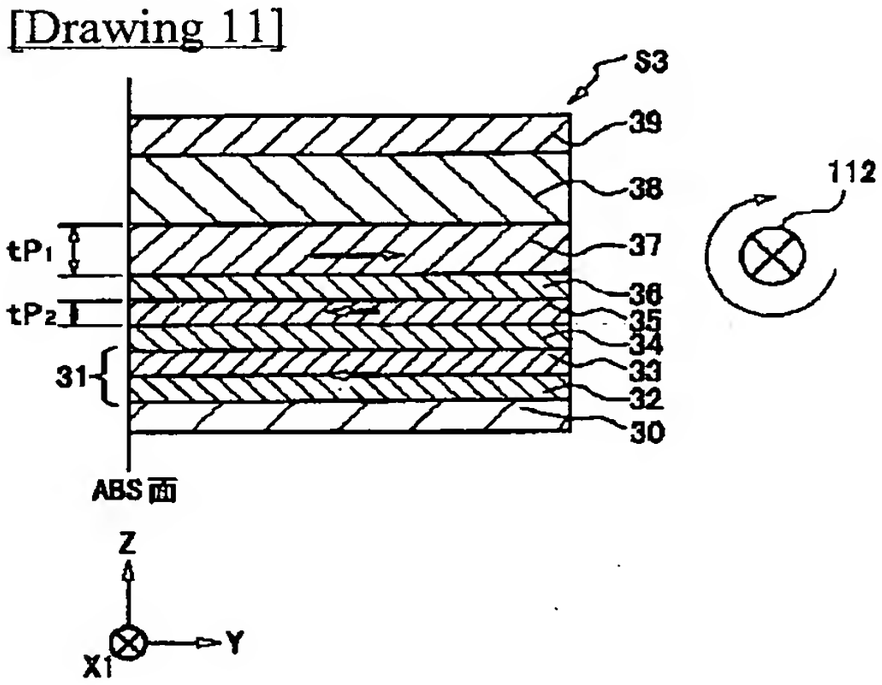
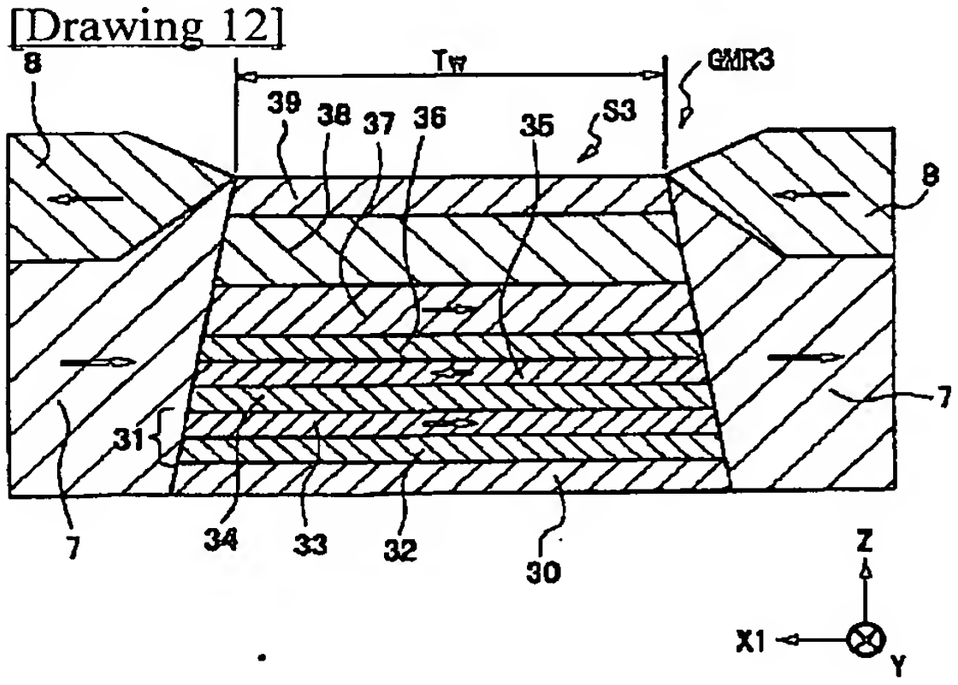
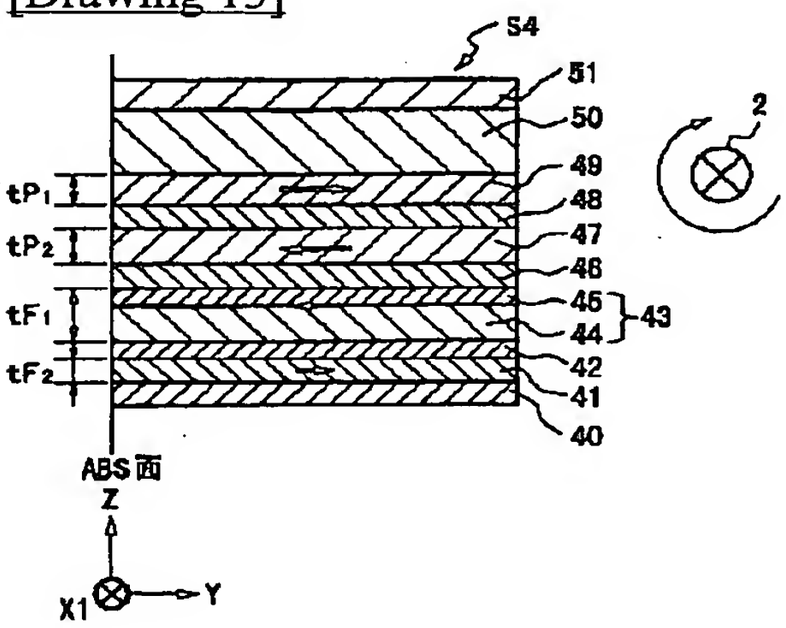


[Drawing 12]



[Drawing 13]



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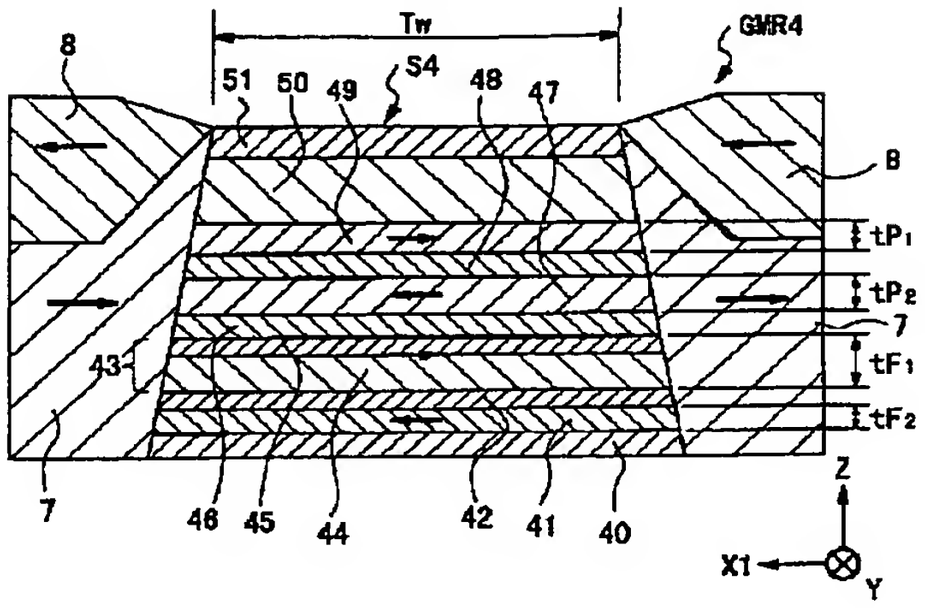

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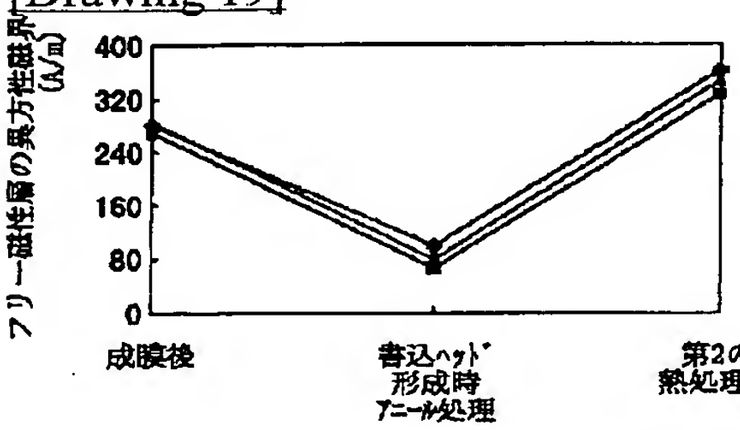

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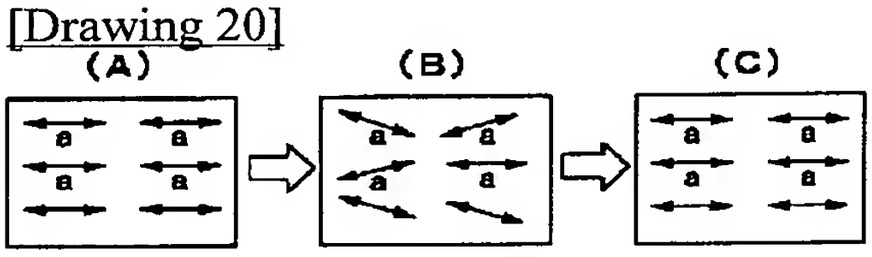

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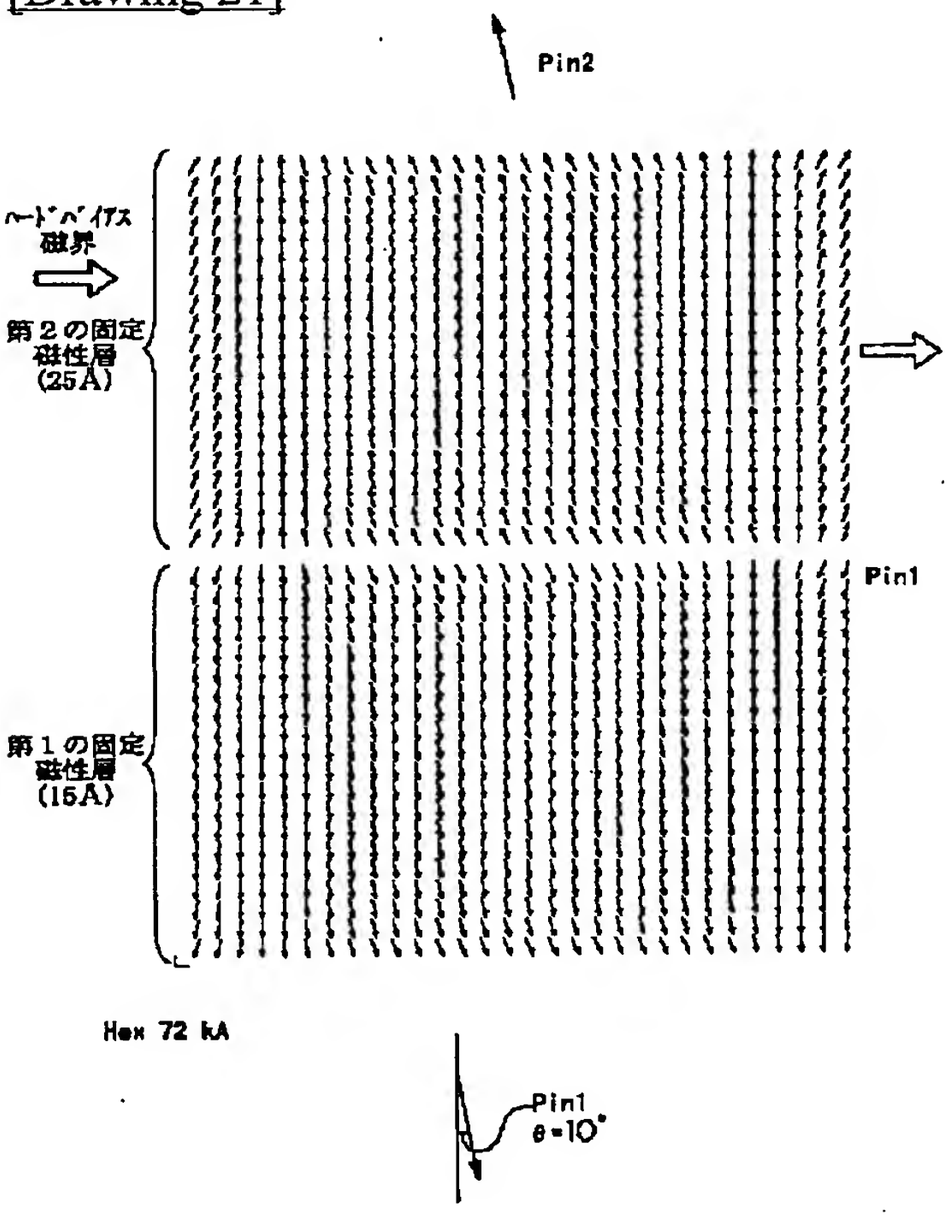
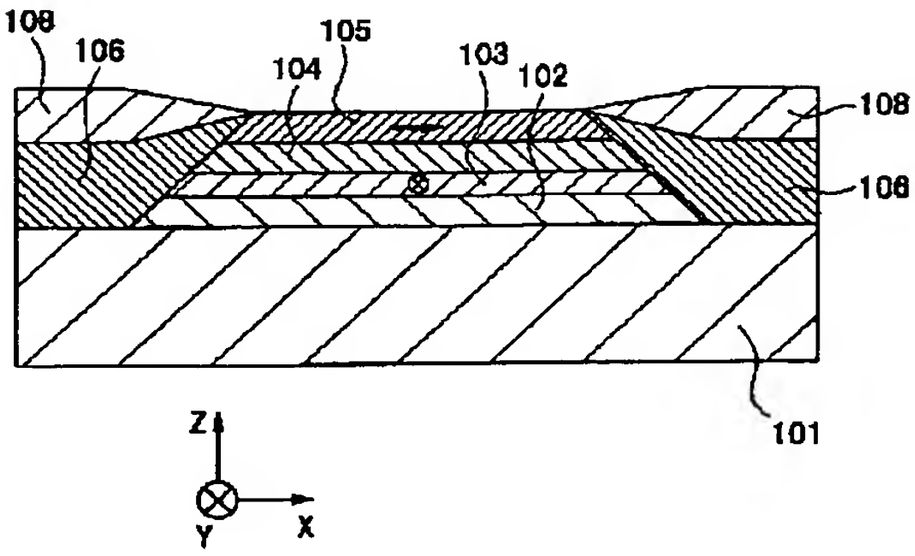


[Drawing 22]



[Drawing 25]

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[Translation done.]